

**ECOLOGICAL STUDIES ON CERTAIN SPECIES OF
GRANIVOROUS BIRDS IN MALABAR**

*Thesis submitted to the University of Calicut
for the Degree of
Doctor of Philosophy
in Zoology*

By

THOMAS A. T.

Department of Zoology,
University of Calicut.

March 2006

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2

Dr. D.N. Mathew

Ornithologist

Professor of Zoology (Retd.) Calicut university, Life Member Bombay Natural History Society, Indian Contact for International Bird Strike Committee

Certificate

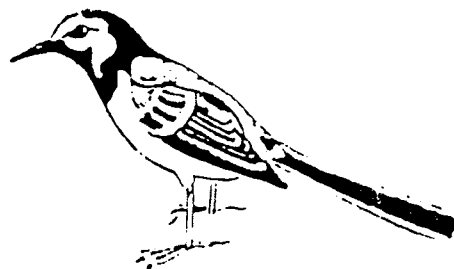
This is to certify that this thesis entitled '***Ecological Studies on Certain Species of Granivorous Birds in Malabar***' is an authentic record of the bonafide research work carried out by Sri. Thomas A.T. under my supervision and guidance and that neither this thesis nor any part of it has previously formed the basis for the award of any degree or diploma.



Dr. D.N. Mathew

March 2006

Chennai



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DECLARATION

*I hereby declare that this thesis entitled “ **Ecological Studies on Certain Species of Granivorous Birds in Malabar** ” submitted to the University of Calicut, for the award of the degree of Doctor of Philosophy in Zoology is a bonafide work done by me and that it has not been submitted earlier in part or in full to any other university for award of any degree or diploma.*

Calicut

31/03/'06



Thomas A.T.

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ACKNOWLEDGEMENT

I express my sincere gratitude to Dr. D.N. Mathew, Professor (Rtd.), Department of Zoology, University of Calicut, for introducing me to the field of Economic Ornithology and for his invaluable guidance and constant encouragement offered to me during the course of this research work.

I am extremely thankful to Dr. U.V. K. Mohamed, Professor (Rtd.) and Former Head of the Department of Zoology, University of Calicut for permitting me to avail the facilities in the Department during my research period.

I am extremely thankful to V. J. Zacharias, former Head of Department of Zoology, St. Joseph's College, Devagiri, Calicut for his constant encouragement, and help rendered to me during my research.

My sincere thanks are due to my colleagues, Dr. George Mathew, Dr. Bobby Jose and Dr. Sabu. K. Thomas, in the Department of Zoology, St. Joseph's College, Devagiri, Calicut for their encouragement and help for the completion of this thesis work.

I extend my sincere thanks to the Principal and the Manager of St. Joseph's College, Devagiri, Calicut for granting me permission to use the laboratory and other facilities of the college for the successful completion of my research work.

I place on record the help rendered to me, by my former students Mr. Vinod K. M.Sc., Sunish M.Sc., and Abhilash Peter M.Sc., in various ways for the completion of this work.

I consider it appropriate to mention the co-operation and help extended to me by the farmers in the different study sites in conducting the survey and obtaining other relevant data used in this research.

Finally, there are many others who have helped me in one way or the other in bringing out this thesis report in its final form. I thank all of them.

Thomas A. T.

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CHAPTER I

INTRODUCTION

Birds, the most fascinating group in the animal kingdom, are an integral part of all natural ecosystems and attract the attention of laymen and scientists alike, because of their interesting biological attributes and the significant role played by them in nature. As in natural ecosystems, often, many birds are associated with agroecosystems for their survival and make some impact on such systems. Since the advent of agriculture birds have been associated with crops, and the importance of birds in agriculture has been highlighted by Salim Ali (1971). Subsequent to the change in land use pattern, which has often resulted in the loss of natural habitats like forests, grasslands and wetlands, many of the birds had to rely on man-made habitats and agricultural crops. In the process of procuring food, birds started damaging cultivated crops. Populations of some of these birds, which were well adapted to live on agricultural crops, have increased enormously in number and became pests. Such bird species comprised mostly of granivorous and frugivorous birds such as doves, pigeons, parakeets, munias, sparrows, weaver birds etc. These birds are often labeled as pests and if their impact on agriculture is sufficient to inflict serious damage, their population become the target of massive management or control efforts (Weins and Dyer 1977).

Granivorous birds are very important to agricultural economy because of the damage they cause to crops. Birds inflicting damage to agricultural crops are often highly visible and the damage is conspicuous (Dolbeer et al. 1994)). The subjective estimates often overestimate losses as much as ten fold (Weatherhead 1982). Objective estimates are therefore important to define accurately the magnitude of bird damage to plan appropriate cost effective control programme (Dolbeer 1981). For such an estimate Stickley (1979) recommended devising a sampling scheme to select the fields and then determining the parts or areas to be analysed for bird damage in the selected fields. Researchers like Weatherhead et al. (1982), White et al. (1985) suggested indirect estimate of bird damage through avian bioenergetics. For instance, according to Elliot (1986), the Red billed Quela, the most dreaded avian pest of Africa, causes loss less than 1% of Africa's total cereal production. In Punjab alone, Dhindsa et al. (1993) estimated an annual loss of Rs. 2.5 crores to stored grains by weaverbirds, sparrows, doves and pigeons.

The mere presence of a bird in a field does not automatically prove the species harmful. For example observation on large conspicuous flocks of common Grackles in sprouting wheat fields during winter has shown that they were eating corn residue from the previous crop (Dolbeer et al. 1994). Thus critical and careful observations are necessary to identify the species causing damage.

From time immemorial, men have developed various devices to repel birds from his cultivated fields which included scare crows, noise making devices, non-lethal devices such as reflecting tapes, spotted balloons with painted eyes, glass balls etc. (Dhindsa et al. 1993). Though these are effective in repelling birds in the initial stages, they become ineffective in the long run as birds become habituated to these devices. Thus the natural response of farmers has been to kill the birds to reduce their depredation, which appear to be more effective than the non-lethal ones. This included shooting, poisoning etc. Dolbeer (1998) reviewed the status and potential of lethal means for reducing bird damage in agriculture. He tried to focus our attention on the fact that most field evaluation of legal control techniques has put far more emphasis on the number of birds killed than on how much damage was eliminated in relation to the cost of control. Killing of birds to protect agricultural crops are now viewed negatively as new laws are enacted to protect them. In addition research has revealed that agricultural losses caused by birds are not often as great as initially estimated (Dyer and Ward 1977, Weatherhead et al. 1982, Dolbeer 1988) and that many pest species also contribute beneficial roles to man (Bendel et al. 1981).

The beneficial role played by birds in agriculture and forestry has often been overlooked. Birds have an important role in the dissemination and dispersal of plants through pollination and seed dispersal and in the destruction of large number of pests; mostly insects and rodents to some extent (Ali

1971). For determining whether any particular bird species is beneficial or harmful in a particular agro ecosystem, factors such as age, food habits, breeding, status, seasonal occurrence and the diversity of food available in the environment are to be studied (Parasharya 1994). Hence a species beneficial in one season may be harmful in another season. Similarly a species that is a pest to one crop may be beneficial to another. It may also be possible that a species may be playing dual role at the same time in the same eco system.

The role of birds in controlling insect pests was recognized as early as 1335, when the civic authorities of Zurich issued an order for the protection of birds as enemies of insect pests (Parasharya 1994). Insectivorous birds are used in biological control, the first known example is the introduction of the Indian Myna (*Acridotherus tristis*) introduced in Mauritius from India to control the Red Locusts (*Nomadacris septemtositiata*). Several species of birds are reported to prey on insect pests of agricultural crops in India. Mason and Lefroy (1912) were the first to study the food habits of birds in the agricultural environment and identified several bird species. Hussian and Bhalla (1937) and Mathew et. al (1980) have also studied the food habits of birds on similar lines and highlighted the importance of birds in controlling insect pests.

Several studies based on the gut content analysis have shown that birds such as Starlings, Baya and House Sparrows, which are blamed for causing damage to crops feed extensively on insect pests during their breeding season

(Ali 1979, Mathew 1976, Parasharya 1994). According to Ali (1979) a pair of Starlings have been observed to bring caterpillars, grass hoppers, locusts etc. to their nestlings 370 times a day. This shows that where birds have not been unwisely interfered with, they contribute one of the most effective natural checks upon insect numbers. Hence when birds are blamed for their damage to agriculture, their service to mankind by way of controlling pests have often been overlooked.

Rice is the staple food of Kerala and a total of 537608 ha area in the state is under rice cultivation (Mathew and Dev.1997). But very little is known about the diet of most granivorous birds of this region and the damage they inflict on crops. In order to evaluate the role of birds in natural and agroecosystems, we should know about their population and feeding ecology. Paddy field is a transient wetland habitat, as its plant cover, water profile, and animal assemblages change with season. Birds form part of this ecosystem at all stages of paddy growth and their occurrence varies temporarily with fine changes in the structure of this ecosystem (Jafer 2000). Preliminary observations carried out in northern Kerala have shown that birds such as parakeets, teals, ducks, moorhens, pigeons, doves, munias, sparrows and weaverbirds cause much damage to paddy in its different stages of growth. In addition parakeets and barbets are known to cause considerable damage to vegetable gardens and orchads. In fact no serious scientific study has been done on the extent of damage caused by birds in Kerala, a state that rely

heavily on agriculture. Hence as a pioneer step, a study on the feeding habits of major granivorous birds such as parakeets, pigeons and munias and their impact on the paddy cultivation of Malabar, was initiated. In this work attention was given mainly to three species of granivorous birds namely, the Spotted Munia (*Lonchura punctulata*), the Blue Rock Pigeon (*Columba livia*), and the Rose-ringed Parakeet (*Psittacula krameri*). The hypothesis that these birds are not natural pests on agricultural crops like paddy, and they attained pest status due to the modification or destruction of their natural habitats, is also being investigated.

Objectives

- 1) Studying the occurrence of granivorous birds associated with the paddy fields in the area: Since the granivorous birds selected for this study lived in communities that included several other species of birds, all birds sighted in the study area were recorded. A preliminary investigation on the occurrence of granivorous birds in the study sites was carried out as part of this work.
- 2) Studying the feeding habits of the Spotted Munia, the Blue Rock Pigeon and the Rose-ringed Parakeet and through field observations: For this observations were carried out in the selected paddy fields in the study area. Their feeding patterns on the grains of paddy at its yielding stage were observed. However, the food diversity in the field is not included in this study.
- 3) Determining the food preference of the granivorous birds through captive

study. To examine whether these birds feeding on the grains of paddy are natural pests on paddy, their food preference was tested in captivity. For test feeding different kinds of grains were provided and the food preference was determined on the basis of the percentage of the grains consumed.

4) Estimating the quantity of grain eaten by these birds in captivity and field: The average quantity of grains consumed by each of these granivorous birds in the field and captivity was determined separately. Based on the data collected through field observation, the extent of damage caused by these birds on standing crop of paddy and their damage potential were estimated. The food demand in captivity, g / g body weight was determined and the extent of correlation between the two was investigated.

5) Suggesting cost effective avian management measures to reduce the crop loss. Without understanding the economic status and extent of possible damage inflicted, branding all granivorous birds as pests and subjecting them to indiscriminate killing may lead to their total elimination from the avian communities in this region. This in turn may result in environmental problems and upset the balance of nature. Therefore some suggestions for proper avian management for reducing the crop loss and to protect the bird community are included at the end of this work.

The study was centered in and around Calicut* and Malappuram districts

* Also known as Kozhikode

of Kerala. Seven paddy fields in the region were identified for the study and field observation was conducted for the collection of data. Captive experiments were conducted to determine the food preference of the granivorous birds selected. A survey of the avifauna (Appendix III.a) associated with paddy cultivation in the area at its yielding stage also is included as part of this work. The data collected were analysed with appropriate statistical tools.

However, the study had some limitations. Since this research work was conducted as a part-time programme, year long observations on the feeding ecology of the granivorous birds selected were not possible. Hence the food habits of these birds when paddy grains were not available in the field were not investigated. Similarly, the data collected on the bird community associated with paddy cultivation were seasonal and therefore, inadequate for the study on population parameters. Further studies are required to investigate these aspects.

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CHAPTER II

REVIEW OF LITERATURE

The problems of granivorous birds have been studied extensively all over the world. The studies on quela by Ward (1965, 1971, 1972 and 1973) were the most exhaustive and pioneering in this field. Some other notable works in this area are, pest control in rice (Murton and Wright 1968), seed selection by pigeons (Brown 1969), bird damage to fruit crops by Brown (1974), study on the resources of desert granivores by Price and Joyner (1977), study on the energetics of granivorous bird communities (Weins and Dyer 1977), adaptive correlation of granivory in birds (Wiens and Johnston 1977), population dynamics of House Sparrow (Dyer, Pinowski and Pinowska 1977) , impact of granivorous birds in ecosystems (Weins and Dyer 1977), food preference of some avian rice field pests of Malaysia (Avery 1979), studies on the damage caused by starlings (Feare 1980 and 1984), the study on quela by Bendell et al. (1981), studies on the Redwinged Blackbirds by Dolbeer (1981), feeding and coexistence of sparrows by Pulliam (1985), diet and gut properties of pheasants (Thomas 1986), crop damage by birds in Africa (Elliot 1986), damages to crops caused by birds in central Europe by Pinowski and Zajac (1990), foraging patch selection by shrub steppe Sparrows by Rottenbury and Weins (1993), breeding performance of granivorous farmland birds of Britain (Siriwardene et al. 2000), studies on the diet among granivorous doves

(Perez and Bulla 2000), etc.

According to Feare et al. (1988), Britain's most serious agricultural pest, the Wood Pigeon is known to cause damage worth millions of pounds. In North America, Dolbeer et al. (1994) estimated the annual loss of agricultural crops by birds worth millions of dollars. According to Besser and Brady (1986), a survey conducted in U.S. on the damage inflicted by Blackbirds, feeding on ripening corns, indicated a loss of 3,30,000 tons worth 31 million dollars. Crop damage by waterfowl has also been reported from all over the world. In Europe the maximum crop damage by waterfowl is caused by geese, with swans and ducks having a much less impact (Roomen and Madson 1991).

In agricultural ornithology, several recent studies were conducted in various countries. Coleman and Spurr (2001) investigated the farmer perceptions of bird damage and control in arable crops. Robinson et al. (2002) made an assessment on the post harvest quality of different stubble types for use by seed-eating farmland birds within the agricultural landscape. Other recent interesting works include, Birds and wine grapes: foraging activity causes small-scale damage patterns in single vineyards by Somers and Morris (2002), the impact of farming on over-wintering bird populations by McMahon et al.(2003), lethal control of red-winged blackbirds to manage damage to sunflower by Blackwell et al. (2003), game crops as summer habitat for farmland songbirds in Scotland by Parish and Sotherton (2004), status of Spot-billed Duck damage to direct seeding in submerged paddy field by

questionnaire survey to farmer in Tohoku District by Sato and Azuma (2003), attractiveness of brown rice baits to non-target birds in harvested corn and soybean fields by Linz et al. (2004), Rule-based predictive models are not cost-effective alternatives to bird monitoring on farmland by Chamberlain et al. (2004), effects of alternative cotton agriculture on avian and arthropod populations by Cederbaum and Carroll (2004), whether Danish agriculture maintained farmland bird populations by Fox (2004), study on the breeding habitats of Rose-ringed Parakeet (*Psittacula krameri*) in the cultivations of Central Punjab by Khan et al.(2004), factors affecting rice grain density unconsumed by white-fronted geese in relation to wheat damage by Amano et al.(2004) etc;.

The studies on Economic Ornithology were started in India, by Mason and Maxwell-Lefroy (1912). Ali (1936) pointed out the impact of birds on agriculture and Forestry and emphasized the need for conducting extensive studies in these areas. Many Ornithologists responded to this call, made valuable contributions and gradually Agricultural Ornithology became an important subdivision in the Agricultural Universities in India. Several studies have been conducted in India, in the last three decades, on birds damaging agriculture. Some of the interesting works in this area include, the contributions from, Ramzan and Toor (1971), Simwat and Sandhu (1973), Toor and Ramzan (1974), Mathew (1976), Bhatnagar (1976), Mathew, Narendran and Zacharias

(1980), Dhindsa and Toor (1980), Raju and Shivanarayan (1980), Sitharama and Shivanarayan (1980), Toor and Sandhu (1981) Shivanarayan (1982), Chakravarthy (1988), Mathew et al. (1991), Srinivasulu et al. (1994) etc. Franciscnathan and Rajendran (1982) listed the avifauna of Pondicherry. Majumdar and Brahmachari (1987) studied the avian predation on insects and rodents in a paddy ecosystem. Rajan (1987) studied the synecology of birds in paddy fields of Kerala, Shyma (1998) listed the birds of agriculture crops in Goa. Thirumurthy (1981) studied the insectivorous birds associated with the rice ecosystem at Madurai. Subramanyam and Vereesh (1998) presented the avifaunal pattern in a paddy field at Bangalore. Patyal et al.(2001) studied the use of reflective ribbons as a component of bird pest management in pecan nut orchards.

Shivanaryan et al. (1985) conducted studies on the extent of crop damage by birds in various parts of India under the All India Coordinated Project on Economic Ornithology. Based on the studies under this project, many granivorous birds such as the parakeets, weaver birds and munias were labeled as pests on different agroecosystems. (Anon, 1985,1986, 1990 and 1999). Launching of this project by the Indian Council of Agricultural Research attracted many ornithologists to this area and thereby accelerated the rate of contributions in the field of Agricultural Ornithology. Studies were conducted on crop losses in various parts of India under the project. Authors in the area of Economic Ornithology include, Ali et al. (1982), Parasharya et al. (1986), Rao

and Jayawardhan (1987), Parasharya et al. (1988) Rao et al. (1990), Parasharya and Mathew (1990), Mathew et al.(1991), Dhindsa et al. (1991), Saini et al. (1992) , Chakravarthy (1993), Dhindsa and Saini (1994), Parasharya et al. (1994), Mathew et al. (1994), Bhattacharjee et al. (1998), Chakravarthy (1998), Jagdish et al. (1998), Mathew et al. (1998), Seshachalam and Rao (1998) etc;.

Though several studies on the role of birds in agricultural ecosystems have been done in India in recent years, Kerala which has extensive crop lands, high rainfall and harbour a large number of bird species when compared to other parts of India, has not been subjected to such a study. Kurup (1991) has carried out detailed investigation on the bird fauna of Malabar coast in Calicut and Malappuram districts of Kerala. Recently, Jafer (2000) studied the bird community in different stages of the crop in the paddy field wetlands of north Malabar and Cheruvath (2004) studied the avian diversity and interactions in *Kaipad*, a traditional system of farming in North Malabar.

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CHAPTER III

STUDY AREA

In this chapter the different paddy fields where I have observed the feeding habits of granivorous birds, are described. Seven paddy fields one each at Ummalathoor, Pookkad, Cherruppa, Koolimadu, Peruvayal, Kadakkattupara and Ulliyeri (hereinafter referred to as study sites 1,2,3 ,4, 5, 6 and 7 respectively), in the districts of Calicut and Malappuram(La.11⁰ 15' -11⁰50' and Long.75⁰45 -75⁰ 80 E) were selected for the study- Figure III.a. Paddy was the main crop in these fields.

Climate

Calicut and Malappuram districts have a hot and humid climate. The temperature fluctuated between, 21.6⁰ C (December 1995) and 34.0⁰C (May 1997) during the study period. Generally the temperature remained high during summer, which started from February and extended to the end of April. The rainy seasons started towards the end of May or in the first half of June with the arrival of the southwest monsoon and lasted till the end of September. The highest monthly rainfall was recorded in July 1994. In October-November periods these localities received intermittent heavy rains due to the northeastern monsoon. Generally, humidity remained high during the monsoon season and low during the summer. The maximum humidity (96%) was recorded in July 1994 and it declined up to 62% during December 1995.

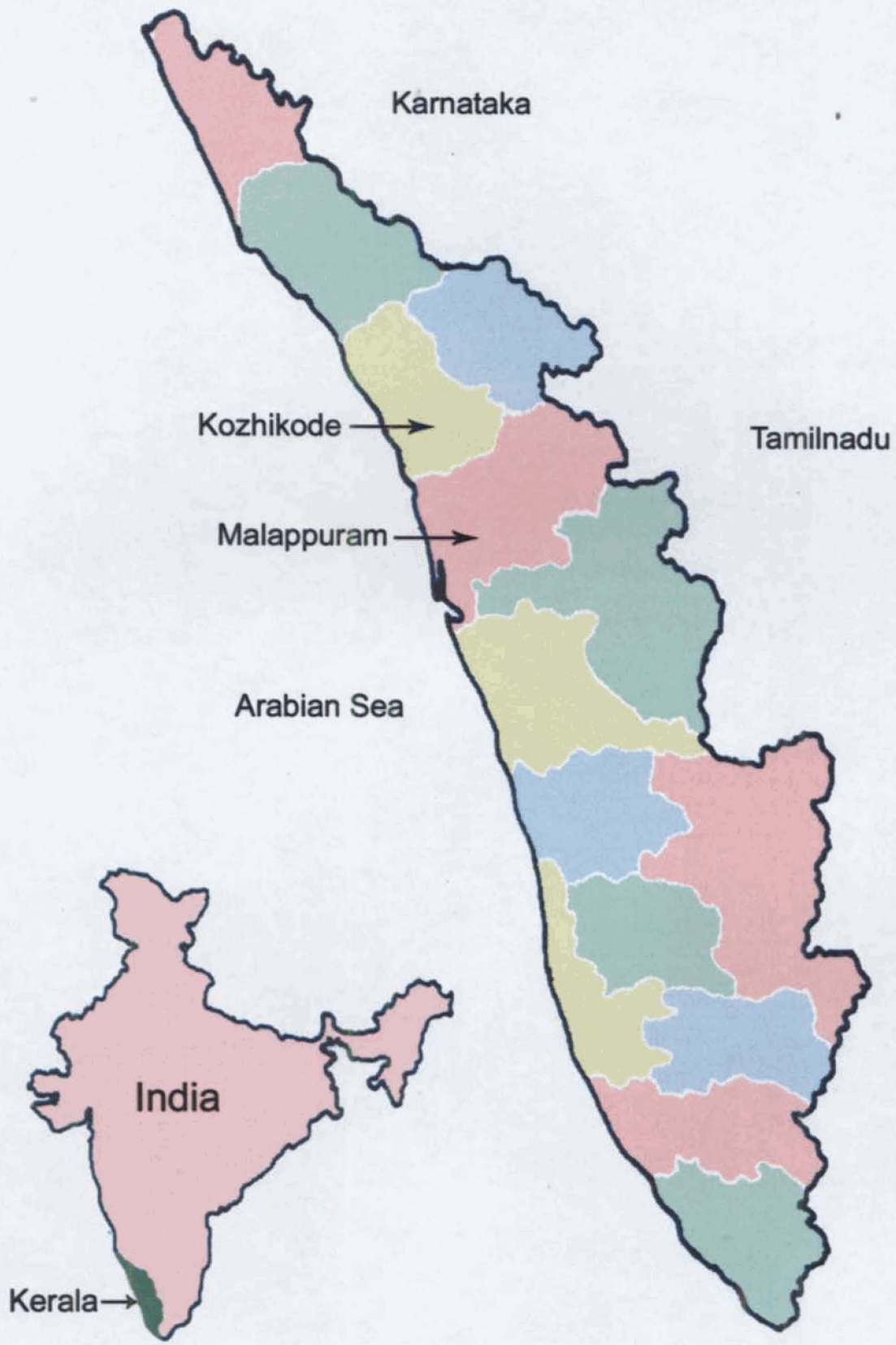


Fig.II.a. Map of Kerala showing Kozhikode and Malappuram Districts



Fig.II.b. Map of Calicut and Malappuram Districts showing the study sites

Physiography

On the basis of the physical features, the Malabar region is divided into three zones as, the low land (below 7.6m. from the sea level) bordering the sea, the midland (between 7.6 to 76m.) consisting of the undulating country east of the low lands and the high land (above 76m.) comprising the forest clad on the extreme east (Logan 1995). The study sites, Pookkad and Kadakkattupara, were in the low land zone and all others were distributed in the midland zone with varying altitude ranging between 15 to 30 meters (Table III.4) from the sea level. The fields in all the study sites had almost similar outlook and were divided by bunds covered with different species of grass. The plots were connected to each other by gaps in the bunds or were directly connected to the mainstream for irrigation. The fields lay between adjoining hillocks that sloped down gradually into the paddy-cultivated area. The slopes were planted with different types of trees (Table III.2). The soil was loamy in the fields and sandy in the slopes. The terrain of the immediate surroundings was undulating with grassy meadows, rocky promontories and ravines.

Irrigation

Like majority of paddy fields of Malabar, cultivation in the study area depended mainly on rainfall and stream water. Narrow streams supplying water to the plots were common in all the study sites. Artificial irrigation facility

was available only in the study site at Ulliyeeri, which was fed by the canals of the Kuttiadi Irrigation Project.

Crops

Paddy was the major crop cultivated in all the study sites and this was cultivated in one to three seasons depending on the availability of water (Table III.1). The third season, 'Puncha' was practiced only in some low lying area where water was abundant during summer and in artificially irrigated area.

Table III. 1 - Paddy cultivating seasons in Malabar.

Season	Colloquial name	Sowing	Harvesting
Autumn	Viruppu	April-June	August-October
Winter	Mundakan	August-October	December-February
Summer	Puncha	January-March	April/May

In the study sites 1 and 5, the periodic flooding of the fields during the monsoon season, forced the farmers to restrict the cultivation to a single season, stretching from June –January/February. They cultivated taller varieties of paddy that withstand the flood and take longer time to attain maturity. In the study site 7, in addition to the normal cultivating seasons, a 'puncha' crop also was raised during January-March by utilizing the artificial irrigation facility.

In addition to paddy, other crops like banana, legumes, rhizomes, tapioca, cucumber etc; were also cultivated in separate plots in the study sites among which banana plantation was the most common.

Cultivation in the adjoining slopes were of mixed nature, dominated by coconut palms(*Cocos nucifera* Linn.) of varying age and height. Arecanut trees (*Areca catechu* Linn.) were also common in the slopes of all the study sites .In addition to these, a variety of other trees also were observed. (Table III.2)

Weeds

In the fields different species of weeds (Table III.3) thrived on the enriched soil, together with the paddy plants and on the mud ridges that divide the field into plots. Among these, the grass *Sporobolous diander* was the most abundant in all of the fields. Scattered thickets of *Pandanus* were a common sight along the sides of the streams irrigating the fields 2, 6 and 7.

Table III. 2 - Common trees in the study area.

Sl.No.	Trees
1	<i>Terminalia bellarica .Roxb,</i>
2	<i>Macaranga peltata</i>
3	<i>Santalum album</i>
4	<i>Phyllanthus emblica</i>
5	<i>Ficus bengalensis</i>
6	<i>Mangifera indica</i>
7	<i>Anacardium occidentale</i>
8	<i>Artocarpus heterophyllus</i>

Table III.3 - Common weeds and grasses seen in the paddy fields

Sl.No	Name
1	<i>Sporobolous diander</i>
2	<i>Cyperus iria</i>
3	<i>Fimbristylis sp.</i>
4	<i>Saccolipsis interrupta</i>
5	<i>Cypera haspen</i>
6	<i>Seteria pallida fusca</i>
7	<i>Echinochloa colona</i>
8	<i>Brachiaria ramosa</i>
9	<i>Paspalum conjugatum</i>
10	<i>Eragrostis uniloides</i>

The features of the study sites are summarized in the table:III.4.

Agricultural Practices:

Mechanical ploughing was followed in larger fields. In smaller fields like the one at Ummalathur conventional type ploughs were used for ploughing with the help of bullocks. In all the fields, sowing, weed control and harvesting were done manually. Fertilizers were added periodically to enrich the soil and insecticides were sprayed in the yielding stage for pest control in all the study sites.

Table III.4 Features of the study sites

Study site	Geographic location	Area of Paddy cultivate -on (ha.)	Physiography	No. of Paddy cultivatin- g seasons	Other crops	Vegetation in and around the field	Other features of interest
Ummalathoor	11°24' N Lat. and 75°57' Long. E, about 9 km. East of Calicut city.	2.5	Located in the boundary zone between the mid and low lands, about 15 m from MSL. Southern side was the slope of a hillock. Other sides were paddy cultivated areas, later converted to coconut plantations. Few water logged ditches close to the field. The soil somewhat rich.	2	Banana plantation in one plot. In addition peas and tuber crops.	Grasses and weeds grew on the mounds and boundaries of the field. Adjoining land was dominated by coconut trees of 10-15 years age. In addition, a thicket of bamboo And trees such as arecanut, Anacardium, Ficus, Macaranga and Mangifera.	Smallest area selected for study. Two sides were bordered by roads with little movements of man vehicles. Many of the neighbouring fields filled for coconut plantation.
Pookkad	11°30'N Lat. and 75°44'E Long., about 25 km away towards the north east of Calicut city.	4.0	Low land area about 4km away from the seashore. Terrain of the immediate surroundings almost plain. A small hillock towards the eastern side. Soil appeared somewhat rich. The field divided into two halves by a mud road without any vehicular traffic. A vast wetland area about 100m away from the western border.	2	2-3 year old coconut trees on the ridges separating the plots. Tuber crops, banana plants, and peas also cultivated.	Different types of grasses and weeds. A thicket of Pandanus on the sides of the stream. The adjoining vegetation comprised mainly of trees such as coconut, arecanut, Mangifera, Santalum, Phyllanthus, Terminalia, etc.	Very near to the sea coast. A vast, water logged area lied near to the field. A road without much movement of man and vehicles divided the field into two halves.
Cherruppa	11°23'N Lat. and 75°59'E Long. About 24 away from Calicut city, towards the east.	30	Located in the border zone of midland towards the lowland. About 15m from MSL. The soil appeared rich. The southern and eastern sides slowly elevated in to small hillocks. Water logged ditches seen near the field.	2	Cassava cultivated in a few adjacent plots. Besides, banana plants, peas and cucumbers	Grasses and weeds grew on the mounds and boundaries of the field. Adjoining cultivation dominated by coconut and arecanut trees. Other trees included, Mangifera, Terminalia, Macaranga, Santalum, Anacardium etc; also occur	Some of the neighbouring plots converted into ditches. Main road with moderate vehicular traffic run close to the field. A small market place near the north-eastern corner making a somewhat semiurbanised appearance.
Koolimadu	11° 24'N Lat. and 76°1'E Long. About 24 km away from Calicut city towards the east.	150	Located in the midland zone, about 20m from MSL. Terrain of the immediate surroundings were almost plain, but the north, south and eastern sides gradually raised into small hillocks. The entire field was divided into two equal halves by a median road with moderate vehicular traffic. The soil appeared rich.	2	Mainly banana plants. Cassava, legumes and Tuber crops also cultivated.	Different types of grasses and weeds in the field. Arecanut and coconut trees dominate in the cultivated land surrounding the field. Other trees included Anacardium, Ficus, Macaranga, Santalum, and Mangifera also found.	The largest among the sites selected for study, divided into two halves by a road with little vehicular traffic.
Peruvayal	11°25'N Lat. and 75°58'E Long., about 12km, towards the east of Calicut city.	11	Low level paddy fields, about 15 m above MSL, in the boundary zone between the low and mid land zones. Terrain of the immediate surroundings plain. The southern and northern sides slowly elevated as the slopes of the neighbouring hillocks. Some adjoining plots left uncultivated towards the east. The soil appeared somewhat rich.	1	Banana plants cultivated in a few neighbouring plots. Other crops included Cassava and legumes.	Different types of grasses in the field. In addition, the vegetation of the adjoining cultivated land comprised mainly of coconut trees. Other trees included Mangifera, Terminalia, Macaranga, Santalum, Anacardium etc; also found	Near to a market place and road with moderate traffic. somewhat semiurbanised appearance.
Ulliyeeri	11°33'N. Lat. and 75°48'E Long. About 40 km, away from Calicut city towards the northeast.	40	Located in the midland zone, about 50m. from MSL. The terrain was almost plain towards the north and south. The western side was gradually elevated in to a hillock. The soil appeared rich.	3	Mixed cultivation of arecanut and banana plants in a plot. Other crops included tubers and legumes.	Grasses, weeds and Pandanus grew along the sides of the field. The adjoining cultivation was dominated by coconut and arecanut trees and banana plants. Other trees included, Mangifera, Terminalia, Macaranga, Santalum, Anacardium etc also found.	The only selected site with artificial irrigation facility and with the highest altitude. Paddy cultivated in three seasons.
Kadakkattu para	10°58'N. Lat. and 75°57'E Long. About 22km away from Calicut city towards its south.	75	Located in the low land zone, about 10m above MSL. The north-eastern sides elevated abruptly into a hill. The southern side was a slightly raised, and towards west the terrain was almost plain. The soil appeared very rich.	2	Young arecanut trees in two plots. Banana plants in a few marginal plots. In addition, Cassava, cucumbers and legumes also	Different types of grasses and weeds. Trees like, Mangifera, Terminalia, Ficus, Macaranga, Santalum, Anacardium Phyllanthus, Anacardium etc; also found.	Second largest field selected for study. No vehicular traffic near the field and minimum movement of man in and around the field.

Summary

Seven Paddy fields located in the Malabar region of Kerala were selected for this work. They represented the paddy fields of this region in different aspects like geographic location, physiographic features, rainfall, climatic conditions, crop layout, agricultural practices and crop damage by birds invading paddy cultivation. These fields were distributed in the low and midland zones. The cultivating seasons ranged from one to three and in all except one field artificial irrigation facility was not available.

a. Ummalathoor



b. Pookkad



22B

10

PLATE II

a. Cherruppa



b. Koolimadu



a. Peruvayal



b. Ulliyeri



a. **Kadakattupara**



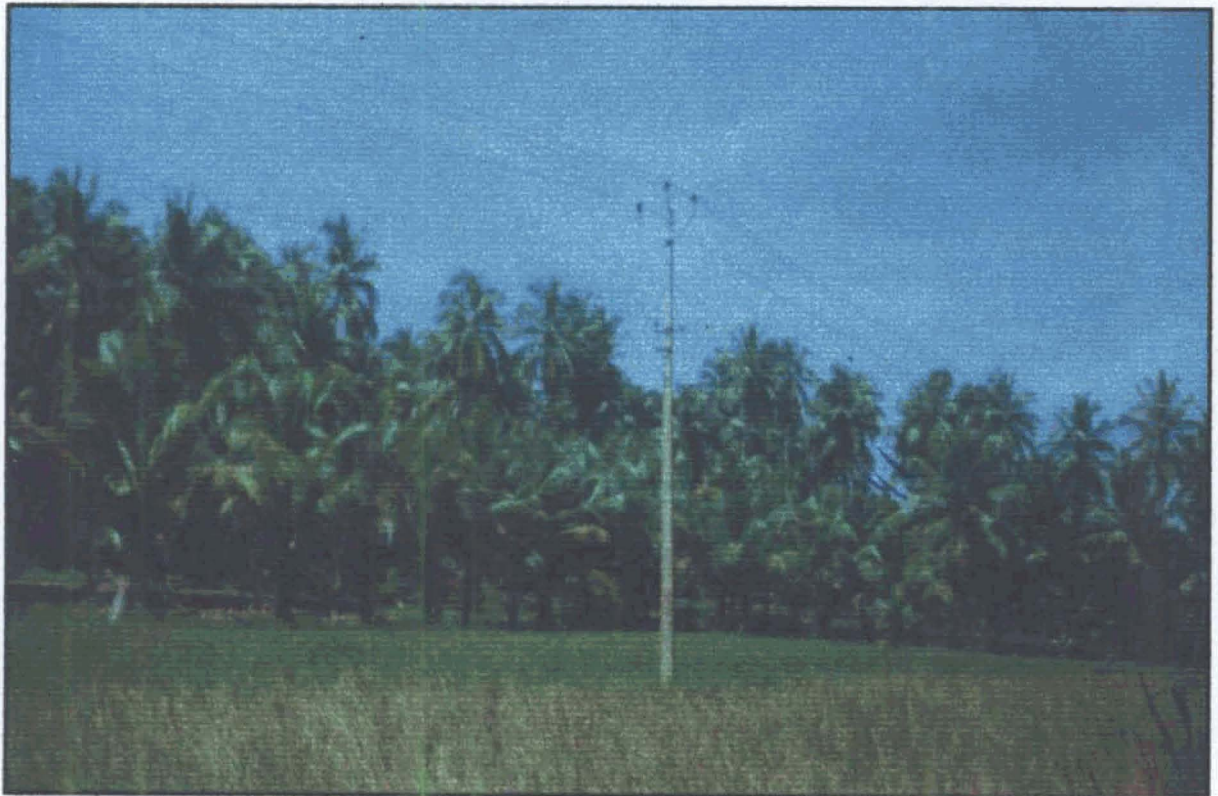
b. **Cherruppa** – A plot with fallen paddy



- a. **Ulliyeeri** - A thicket that provided resting site to the Whitebacked Munia.



- b. **Coconut trees bordering the study site at Peruvayal**



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By

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March 2006

CHAPTER IV

METHODOLOGY

The study comprises observation of selected species of economically important birds in the field and experiments on captive birds to test their preference to grains and feeding capacity, when they are provided with different types of grains. This chapter describes the methods adopted for the study.

1. Field Selection and Identification of Birds

Seven localities in the districts of Calicut and Malappuram, not very far from Calicut city were selected for the study. These areas had extensive cultivation of paddy where birds were reported to cause considerable damage to crops. The studies were carried out from September 1993 to January 1998.

Meteorological information like temperature, rainfall and humidity (Appendix I) of the selected area were obtained from the government agencies. Conditions like terrain, adjoining vegetation and vehicular traffic in the neighbouring areas were also recorded. Details of agricultural practices were obtained by interviewing farmers and local people. Intensive observation was recorded from each field for a full season from the milky stage of paddy grains till harvest.

The total number of species of birds in the chosen sites was noted. This was obtained by making visits to each field, once in three days, from 06.30 hr to 09.00 hr and 16.00 to 18.00 hr, over a period of two weeks. An average of 20 hours for each field was spent on observations of these aspects of the birds in the study area. A Carl Zeiss binocular was used to observe the birds and the line-transect method (Gaston 1973) was followed for their survey. For this, a predetermined transect was identified in each field and the birds on either side of it was observed and recorded. The length of transect varied with the field and were determined so as to encompass the field and the major resting sites of the birds visiting there. The data thus obtained from each field were systematically tabulated and made use of to determine the total number of species of birds observed (Appendix – III.a) in the area.

2. Occurrence of granivorous birds

The birds damaging paddy cultivation by feeding on grains were identified and grouped as granivorous birds. Based on the field observation, the occurrence ratio, i.e. the ratio of the number of sites in which the bird was sighted to the total number of sites of each species was determined.

The flock-size of the granivorous birds and the period during which they cause damage to standing crop were observed. Such observations were started from the milky stage of grains and continued till harvest. The birds were counted each time by following the line transect method. The counting was

done along with the general survey of birds or with the study on feeding habits. The observations thus obtained were tabulated and analyzed statistically to obtain the mean (\bar{X}) flock size, standard deviation (σ) and population density of each species, in each of the study site.

3. Feeding habits

The feeding habits of three species of the granivorous birds, the Spotted Munia (*Lonchura punctulata*), the Blue Rock Pigeon (*Columba livia*) and the Rose-ringed Parakeet(*Psittacula krameri*) were observed in the study sites at Kadakkattupara, Cherruppa and Peruvayal respectively. Daylong observations (06.30 hr to 18.30 hr) were recorded for ten days for each species by following the point transect method. For this, several points were selected in each study site for day long observation of the foraging birds.

4. Estimation of crop damage

The mean size of the feeding flock, frequency of the feeding visits, duration of each feeding visit, pattern of grain- collection, the number of grains collected / bird / unit time and the total number of days that the birds invaded the crop in a season were observed and recorded. Then, the percentage of damage inflicted by each species on standing crop was crudely estimated. For this, the mean flock size, total feeding time, number of invading days in a season and the feeding rate of the birds (i.e. the number of grains collected / bird / unit time in the case of Spotted Munia and Blue Rock Pigeon and the

mean number of earheads collected / bird / visit in the case of the Rose-ringed Parakeet), were considered.

The damage inflicted was estimated as follows,

(a) Spotted Munia

Total number of paddy grains damaged or consumed / day/ bird,

$$N = n t r / 5$$

Where ' n ' is the mean number of feeding visits / day, ' t ' is the mean time (min.) taken for a visit and ' r ' is number of grains consumed in 5 minutes.

(b) Blue Rock Pigeon

Total number of paddy grains damaged or consumed / day / bird,

$$N = n t r$$

Where, ' n ' is the mean number of feeding visits / day, ' t ' is the mean time (min.) taken for a visit and ' r ' is number of grains consumed / minute.

(c) Rose-ringed Parakeet

Total number of paddy grains damaged or consumed /day/ bird,

$$N = n r m$$

Where ' n ' is the mean number of feeding visits / day, ' r ' is the mean number of earheads collected by a bird / visit and ' m ' is the average number of grains in an earhead.

Percentage of crop damage

The weight (g) of grains consumed or damaged / day / bird, (C) was determined in each case, and it was multiplied by the flock size, (s) and the number of days of invasion, (d) to predict the total damage inflicted (L) by a flock in a season.

i.e., The weight of paddy consumed or damaged / day / bird;

$$C = N / \text{number of grain in one gram of paddy}$$

The total damage inflicted by a flock in a season,

$$L = C s d$$

Then ,

Percentage of damage inflicted by a flock in a season = $(L / W) \times 100$,

where, ' W ' is the average expected yield in a season in a field.

Estimation of Damage Potential

The damage potential or the capacity to inflict damage on standing crop by the Spotted Munia, the Blue Rock Pigeon and the Rose-ringed Parakeet were determined in terms of the weight (g) paddy grains consumed or destroyed by a flock in a season. The damage potential ' D ' was considered as a function of, ' C ' - the total weight of

grains (g) consumed or damaged / day/ bird, and ' d ' -the number of invading days in a season, i.e.,

The damage potential of an individual bird,

$$D = C d$$

4. Studies on captive birds

Three species of granivorous birds, the Spotted Munia, the Blue Rock Pigeon and the Rose-ringed Parakeet were observed and tested in captivity to study their preference to different types of grains provided. The experimental study was done in three sessions, during the period December 1995 and January 1998. Samples of the wild birds were collected from the field and subjected to acclimatization for a period of one week. During this period the birds were fed with the grains of different cereals. In the case of Spotted Munia, the seeds of the most common grass in all the study sites, *Sporobolous diander* also was provided. After the acclimatization period, in each case, 10 healthy birds were selected and divided into two groups as experiment (E) and control (C) of size five each .The birds were weighed before and after the test feeding to get the average body weight and to see if the birds had lost any weight.

Captive feeding

Same methodology was followed to determine the food preference of the three species. The experiment and control groups of 5 birds each was put in

separate wire mesh cages of the size 50x50x150cms. The cages were kept in a well-ventilated part of the laboratory. In each case the test was for ten days and the feeding time was 06.00 hr– 18 hr. Drinking water was provided throughout the feeding time for the ' E ' group, whereas it was restricted in the ' C ' group by providing them with water at one-hour interval with the supply period lasting for ten to fifteen minutes. This was to maintain the availability of water in the ' C ' group birds almost similar to that in the field where the birds had to visit the neighbouring sources for water at intervals. Every morning each group was supplied with equal quantities of the grains of Italian Millet (*Setaria italica*), Common Millet (*Panicum milaceum*), Ragi (*Eleusine corocana*) and Paddy (*Oryza* sp.). In addition to these items, seeds of the grass, *Sporobolous diander* in the case of the Spotted Munia, and grains of Wheat (*Triticum* sp.) in the case of Blue Rock Pigeon and Rose ringed Parakeet, were provided. The food grains were provided in separate identical plastic trays kept inside larger off-white plastic trays. An off-white cotton cloth was spread on the floor of the cage to collect the discarded grains that fell off the bird's beaks. In the evening, after the feeding time, the left over grains and seeds in both the cages were collected, sorted, and weighed to determine the weight of each item consumed by each group. In each case, this procedure was repeated for ten days, for both the groups.

The data collected from captive feeding was compiled to obtain the following values in each of the three cases.

- (1) The total weight of food items consumed by each group for ten days.
- (2) The mean weight of the grains consumed / bird / day, \bar{X}_1 and \bar{X}_2 , for the experimental and control groups respectively.
- (3) The mean weight of each food item consumed / bird / day for the experiment, control and also for both the groups combined.
- (4) The percentage of each food item consumed by each group for ten days.

The difference between the mean weight of the grains consumed / bird / day, \bar{X}_1 and \bar{X}_2 was tested by the t - test, to see whether it was significant or not, or whether the food intake by the experiment and control groups differ significantly. The difference between the mean weight of each food item consumed / bird / day for the ' E ' & ' C ' groups combined was tested statistically by the analysis of variance (ANOVA) by the Minitab (release 13.1) statistical software, to see whether the difference between the mean weight of each food item consumed was significant or not. Preference to the grains was assigned in each case, based on the result obtained by the ANOVA and the percentage of each food items consumed by each group.

In order to obtain the actual (dry) weight of food consumed in each case, the water content of the grains provided was estimated. For this 100 g of

each food item provided was kept in the oven at 110⁰ C and weighed at an interval of one hour. This was repeated till the weights became constant. From this the percentage of water content in each item was estimated. Based on this the actual mean weight of each food item consumed and the actual mean weight of total food items consumed / day/ bird were determined. The value thus obtained was divided by the mean body weight to get the mean weight of food consumed/gram body weight of each species.

Correlation between the body weight and the weight of food consumed

The extent of correlation between the two variables, the mean body weight (X) and the actual mean weight of food consumed / gram body weight (Y) of the birds was studied graphically by the scatter diagram and also by calculating the co-efficient of correlation ' r ' (Ninan 1980). In this part of the study, the relevant data concerning the Southern Whitebacked Munia (Thomas -unpublished) also was considered. For the scatter diagram the X and Y-axes were graduated for the mean body weights and the mean dry weight of food consumed (g)/ gram body weight respectively. For each species, the points representing these values were plotted on the graph to get the scatter diagram.

The numerical value showing the extent of correlation between the two variables X and Y was obtained by applying the formula,

$$\text{Co-efficient of correlation, } r = \frac{P_{xy}}{S_x S_y}$$

Where, P_{xy} is the average of the joint variation of the two variables X and Y ,

$$\text{i.e. } P_{xy} = \frac{\text{Sum of the products of deviation of } X \text{ from } \bar{X} \text{ and } Y \text{ from } \bar{Y} \text{ for each bird}}{\text{Total number of pairs of observations}}$$

\bar{X} and S_x are the mean and standard deviation of body weight respectively, and \bar{Y} and S_y the mean and standard deviation of weight of food(g)/ gram body weight respectively.

Regression analysis

The regression analysis of the two variables, X and Y were made by forming the regression equations. The regression equation, X on Y is written on the assumption that, as the X value changes there is a corresponding change in the Y value. Similarly, the equation Y on X is written on the assumption that as Y value changes, there is a corresponding change in the X value.

The regression equation X on Y is,

$$X - \bar{X} = \frac{P_{xy}}{S_y^2} (Y - \bar{Y})$$

Similarly, the regression equation Y on X is,

$$Y - \bar{Y} = \frac{P_{xy}}{S_x^2} (X - \bar{X})$$

Using the regression equation X on Y , the most probable value of X (body weight) can be predicted for a given value of Y (weight of food consumed/ gram body weight). Similarly, the regression equation Y on X can be applied to predict the value of Y (weight of food consumed/ gram body weight) for a given value of X .

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CHAPTER V

OCCURRENCE AND FEEDING HABITS

Observations were carried out on the feeding habits of the Spotted Munia, the Blue Rock Pigeon and the Rose-ringed Parakeet in the paddy fields at, Kadakkattupara, Cherruppa and Peruvayal respectively. Since these birds were part of the bird communities of the area, a general survey of the avifauna (Appendix – III.a) was carried out. A preliminary study on the occurrence of the granivorous bird assemblages associated with the paddy agro ecosystems in all the seven study sites were also conducted as part of this investigation. This chapter presents the information collected on these aspects and observations on the feeding habits of the above three species of birds.

OCCURRENCE

The granivorous birds sighted in the study sites are presented in the table V.1. Although six species of granivorous species were identified, except for the Blue Rock Pigeon none of the birds were common to all the study sites. A maximum of five species were spotted in the study site Kadakkattupara, while four species were seen in three sites; Ummalathoor, Pookkad and Cherruppa, three in the site at Peruvayal and the minimum of two species were seen in the site at Koolimadu and Ulliyeeri. The magnitude of total number of species of granivorous birds in the study sites was in the order;

Kadakkattupara > Ummalathoor = Pookkad =

Cherruppa > Peruvayal > Koolimadu = Ulliyeeri

Table: V.1: Granivorous birds sighted in the study area.

Birds	STUDY SITES							Total sites
	Ummalathoor	Pookkad	Cherruppa	Koolimadu	Peruvayal	Kadakkattupara	Ulliyeeri	
Blue Rock Pigeon <i>Columba livia</i>	+	+	+	+	+	+	+	7
Spotted Dove <i>Streptopelia chinensis</i>	-	+	+	-	+	-	-	3
Rose-ringed Parakeet <i>Psittacula krameri</i>	+	+	-	+	+	+	-	5
Blossom-headed Parakeet <i>Psittacula cyanocephala</i>	+	+	-	-	-	+	-	3
White-backed Munia <i>Lonchura striata</i>	+	-	+	-	-	+	+	4
Spotted Munia <i>Lonchura punctulata</i>	-	-	+	-	-	+	-	2
Total number of species of granivorous birds sighted	4	4	4	2	3	5	2	

Occurrence Ratio

Out of the six species of granivorous birds identified, the Blue Rock Pigeon was the only one common to all the study sites. The Rose-ringed

Parakeet was a common sight in five and the White-backed Munia was sighted in four of the study sites. The Blossom-headed Parakeet and Spotted Dove were seen in three of the fields. The Spotted Munia showed the minimum distribution as they were seen only in two study sites i.e., at Kadakkattupara and Cherruppa. Thus, based on the distribution, the granivorous birds identified observed in the study sites fell into five categories with occurrence ratios as, 1, ,5/7,4/7,3/7 and2/7 (Table V.2).

The magnitude of the occurrence ratio can be expressed as;

**Blue Rock Pigeon > Rose-ringed Parakeet > White-backed Munia
> Blossom-headed Parakeet= Spotted Dove > Spotted Munia.**

Table V. 2 Occurrence ratio of the birds observed in the study area.

Occurrence Ratio	Granivorous Birds
1	Blue Rock Pigeon
5/7	Rose-ringed Parakeet
4/7	White-backed Munia
3/7	Spotted Dove and Blossom- headed Parakeet
2/7	Spotted Munia

Flock size

The flock sizes of the granivorous birds in each of the study site were

Table V.3. Mean flock sizes of the granivorous birds sighted in the study area.

Birds	Mean flock-size of granivorous birds in the study area						
	Ummalathoor	Pookkad	Cherruppa	Koolimadu	Peruvayal	Kadakkattupara	Ulliyeri
Blue Rock Pigeon	4.8	12.6	29.4	18.6	10.8	24.6	8.4
Spotted Dove	-	2.6	2.0	-	2	-	-
Rose-ringed Parakeet	6.6	7.4	-	10.6	9.1	10.4	-
Blossom-headed Parakeet	2.4	8.8	-	-	-	4.2	-
White-backed Munia	16.4	-	11.6	-	-	14.2	38.2
Spotted Munia	-	-	6.8	-	-	13.4	-

observed along with the general survey of birds or with the study on the feeding habits. Based on the data collected, the mean flock size (Table: V.3) and density of population (Table: V.4) of each species of granivorous bird in each study site were determined. The mean flock size varied widely between 2 and 38.2, with the minimum for the Spotted Dove at Peruvayal and Cherruppa and the maximum for the White-backed Munia at Ulliyeri. In majority of cases, the population density was below 1 bird / ha. In the case of the Blue Rock Pigeon and the Rose-ringed Parakeet at Ummalathoor and Pookkad, the

Blossom-headed Parakeet at Pookkad and the White-backed Munia at Ummalathoor the population density was above one. The highest population density was recorded in the case of the White-backed Munia at Ummalathoor and lowest in the case of the Blossom-headed Parakeet at Kadakkattupara.

Table V.4. Population density of granivorous birds sighted in the study area.

Birds	Density of granivorous birds in the study area (Number of birds/ha.)						
	Ummalathoor	Pookkad	Cherruppa	Koolimadu	Peruvayal	Kadakkattupara	Uliyeri
Blue Rock Pigeon	1.92	3.15	0.98	0.12	0.98	0.33	0.21
Spotted Dove	-	0.65	0.07	-	0.18	-	-
Rose-ringed Parakeet	2.64	1.85	-	0.07	0.83	0.14	-
Blossom-headed Parakeet	0.96	2.2	-	-	-	0.06	-
White-backed Munia	6.56	-	0.39	-	-	0.19	0.96
Spotted Munia	-	-	0.27	-	-	0.18	-

FEEDING HABITS

A. Spotted Munia (*Lonchura punctulata*)

The study on the feeding habit of Spotted Munia was carried out at Kadakkattupara from 23 December 1993 to January 1994. The birds fed in the paddy fields from the milky stage of grains till harvest. Since the grains did not

mature uniformly in all the plots, the Munias were seen to shift to plots having grains in milky stage. The duration of attack extended for a period of twenty-seven days.

The observations on Spotted Munia were carried out on a mixed gathering of White-backed Munia and Spotted Munias; the former characterized by clean black throat and breast and white belly and the latter with chestnut throat and breast with whitish under parts with dark scaling. (Grimmett et al. 1999). The gathering contained 38 to 47 munias including 12 to 16 Spotted Munias with mean 13.4 ± 1.36 S.D. and density 0.18 bird / ha. Daily variation observed in the flock size of the Munias is presented graphically in figure V.a. The birds reached the field in small mixed groups of size 4 to 7 and I could not observe any roosting site in and around the study site. The foraging birds used the banana plantation close to the paddy cultivation as a base and cover for visiting the crops of paddy. Both species followed almost identical patterns in feeding. When the size of the gathering increased, the birds were distributed over the field in an area of about 25 m². The birds started feeding by 07.00 hr and remained in the field and in the banana plantations in the adjoining areas upto 11.30 hr. After the morning session of feeding, the munias left the field in small groups, probably for their mid day roosts.

The birds fed in two sessions; from 06.30hr in the morning till 11.30 hr and 15.30 hr to 18.30 hr in the evening. The frequency of feeding visits

Fig. V.a - Variation in the flock size of the Spotted Munia at Kadakkattupara

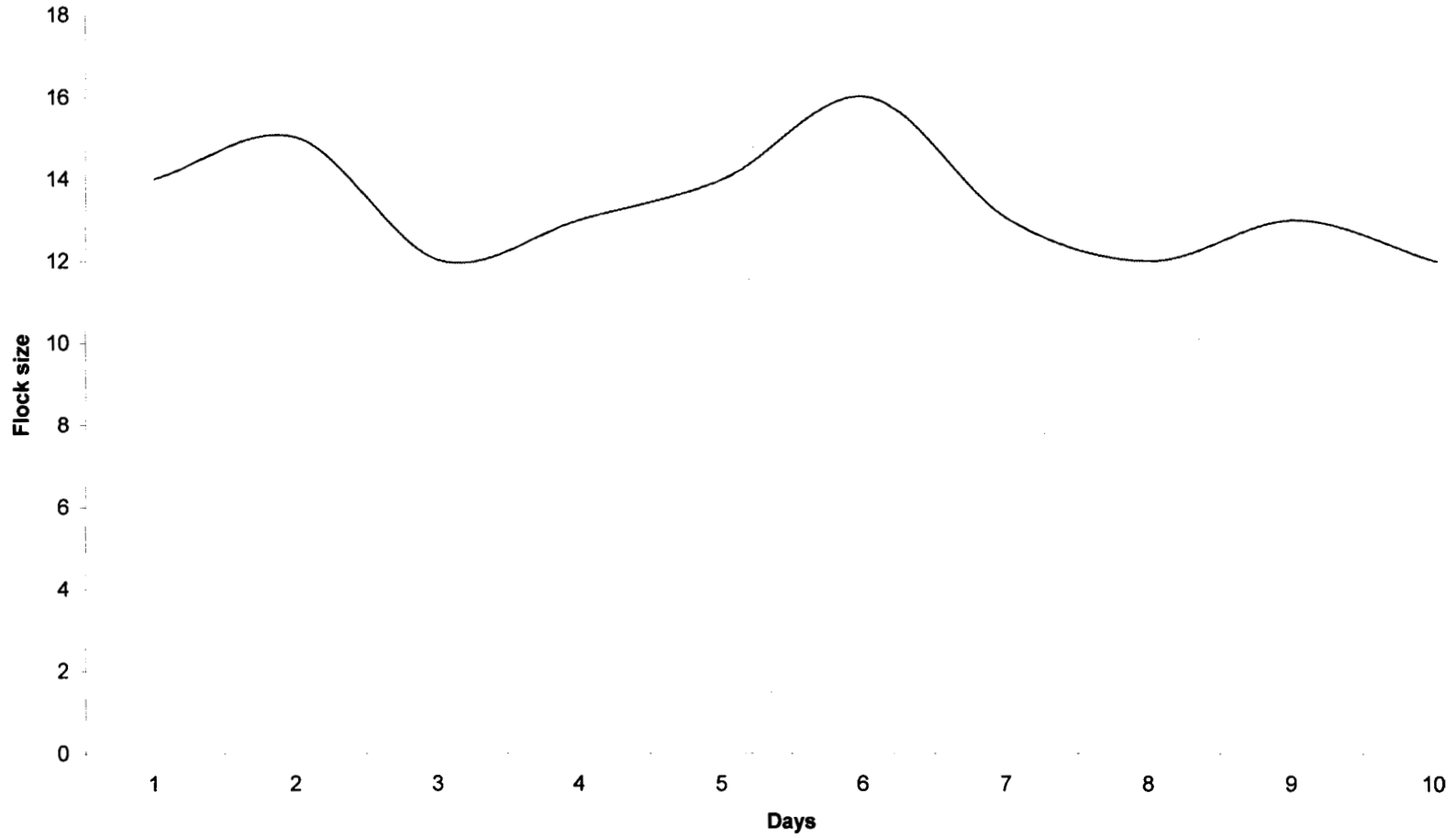


Figure:V.b. - Feeding frequency of the Spotted Munia

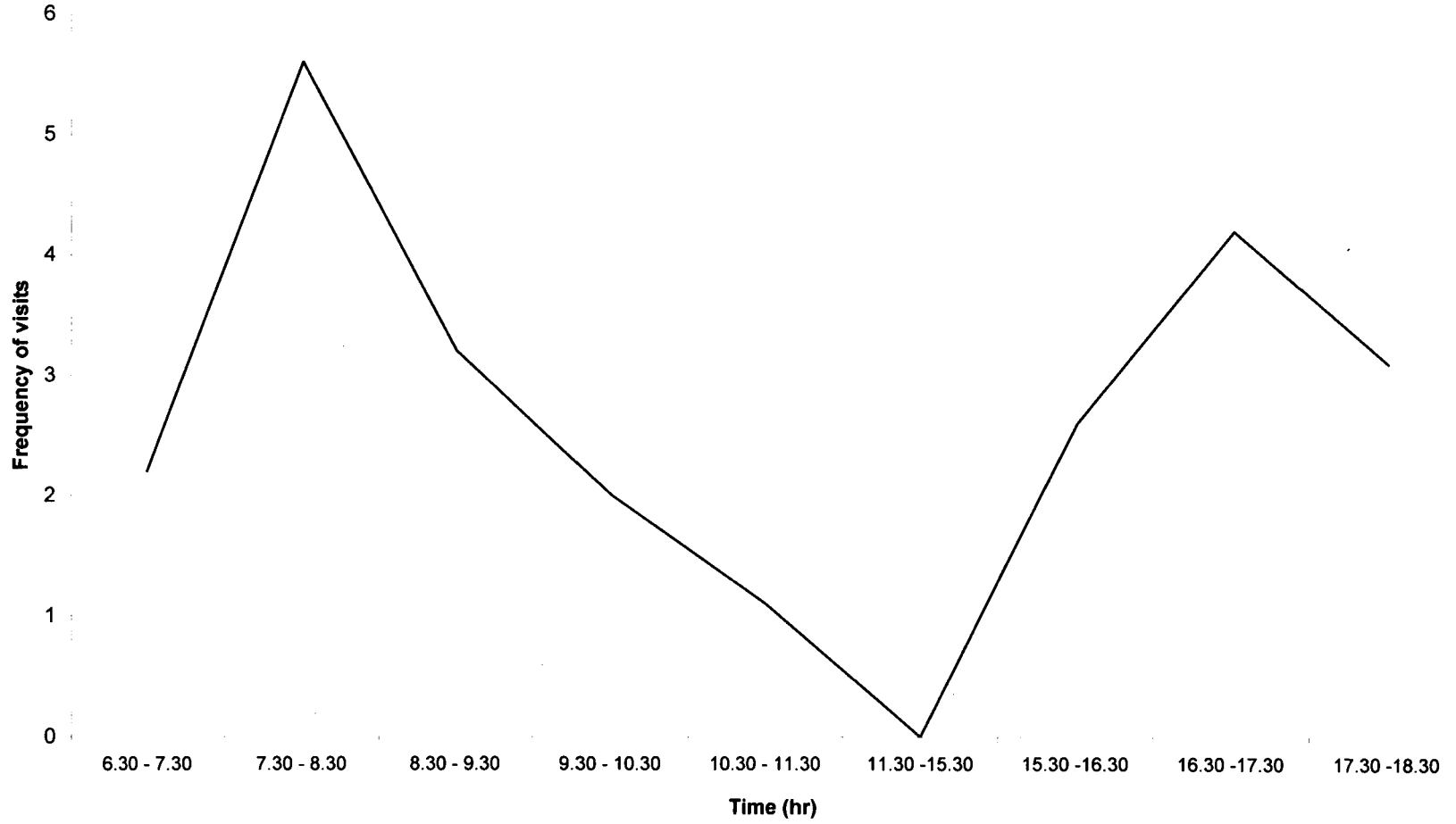
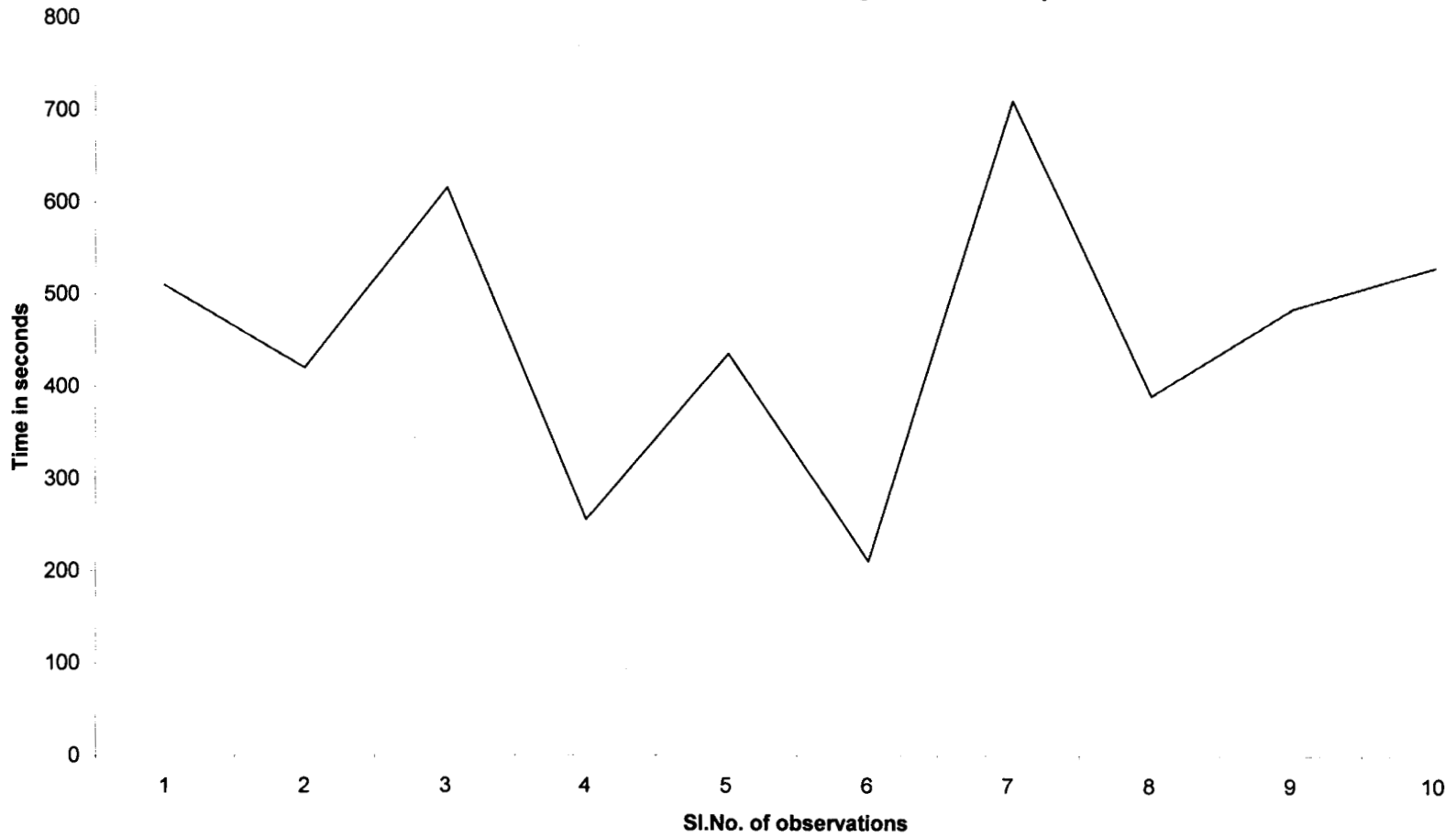


Figure:V.c. - Variation in the duration of feeding visits of the Spotted Munia



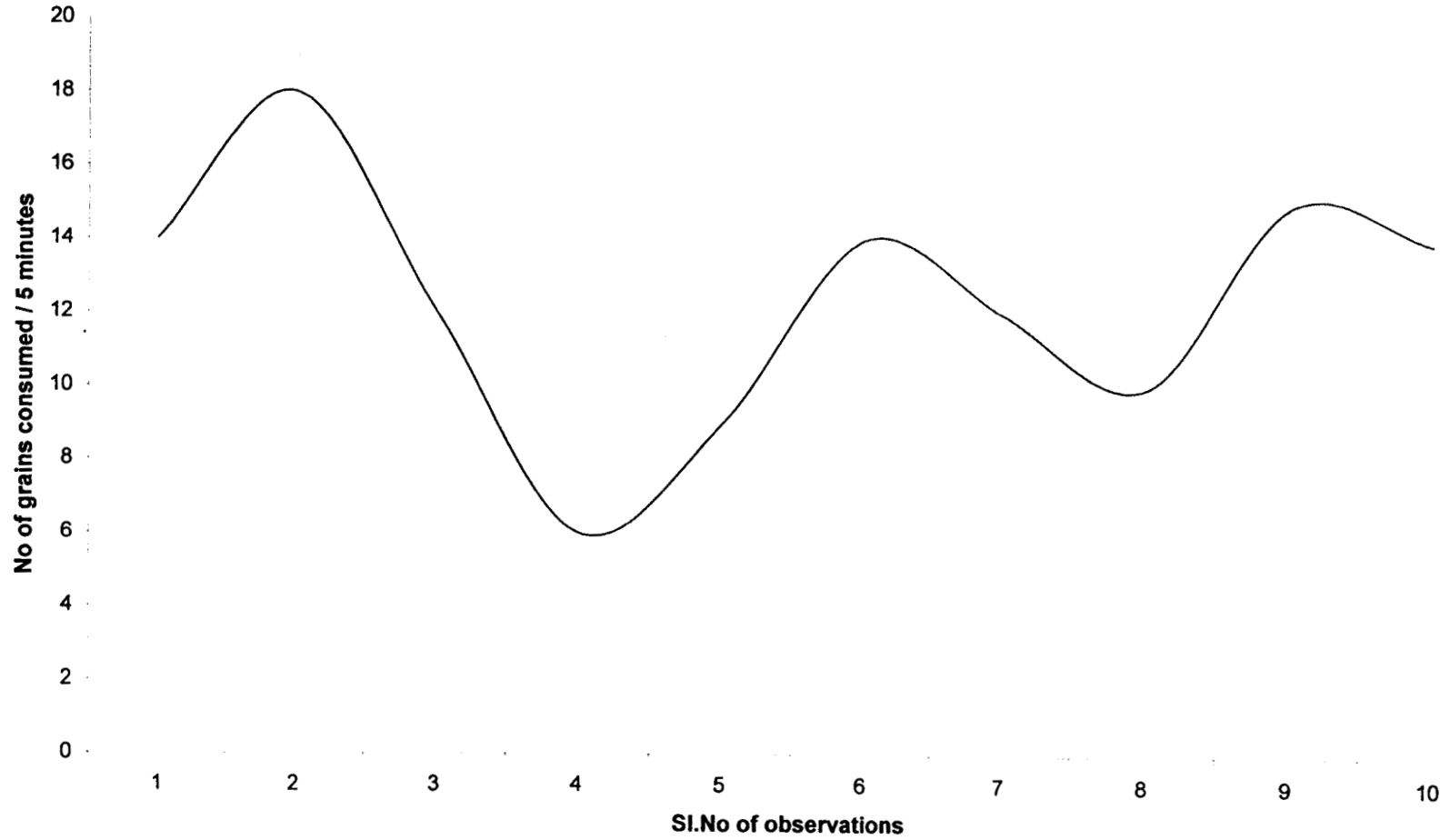
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throughout the day was noted for 5 days from 06.30 hr to 18.30 hr. The peak feeding time was 07.30 hr to 8.30 hr in the morning and 16.30 hr to 17.30 hr in the evening. No feeding was recorded between 11.30 hr and 15.30 hr. Variation observed in the feeding frequency of the Munias is presented in figure V. b

Actual feeding was carried out in small restricted areas of about 25 square meters and it appeared that each member of the group was in sight of the others. The feeding time per visit ranged between 3 min. 30 sec. to 11 min. 50 sec. with mean 7min. 36 sec. \pm S.D. 2 min.23 sec. and is presented in figure: V.c. After feeding for a few minutes, the birds left the field in small groups of three to six and rested on the banana plants. There the birds engaged in activities such as preening and bill wiping. Some of the birds moved to the nearby stream and returned after 3 to 11 minutes.

For feeding, each bird perched on a separate earhead, plucked, dehusked and swallowed the grains one by one. The rate of feeding varied with the individuals with an average of 12.4 grains consumed in 5 minutes, with S.D. 3.23 grains. This observation is presented graphically in figure;V.d. Partially dehusked grains were sometimes dropped. After feeding for one to five minutes from an earhead, some birds shifted to the neighbouring earhead and continued the same pattern of feeding. Usually the birds started feeding from the peripheral areas and gradually proceeded into the center of the rice field.

Figure: V.d. - Rate of feeding in the Spotted Munia



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In the field, the munias appeared to prefer grains in their milky stage. They started feeding on ripe grains when grains in the milky stage were not available and continued feeding on paddy till harvest.

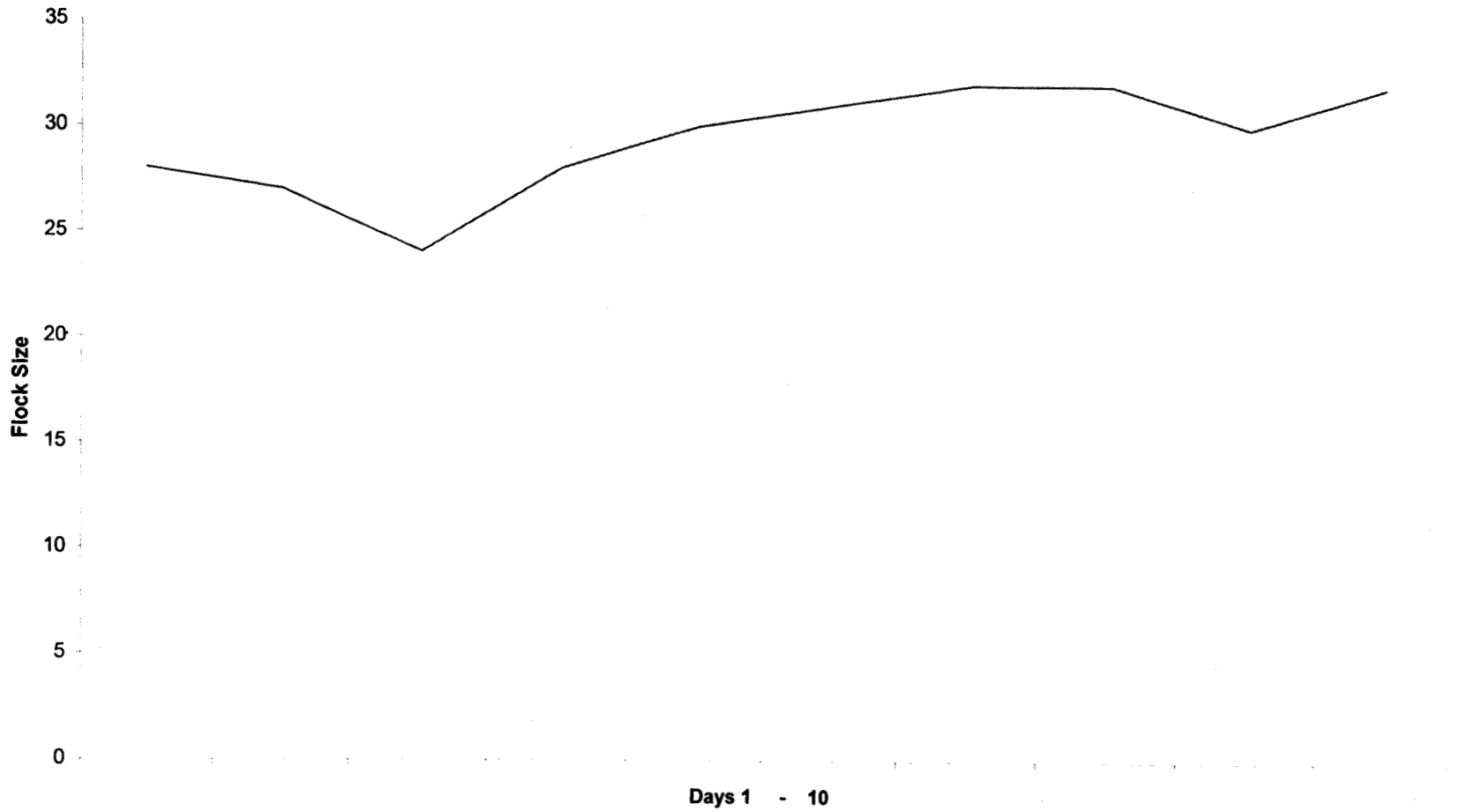
B. The Blue Rock Pigeon (*Columba livia*)

Feeding behavior of the Blue Rock Pigeon was observed in the study site at Cherruppa for ten days, from 22 to 31 December 1996. The Blue Rock Pigeon was a common resident bird in the neighbouring areas of the paddy field and fed the ripe grains of paddy when it became available.

The average size of the feeding flock observed was $29.4 \pm \text{S.D. } 2.498$ with density of population 0.98 birds / ha. Variations observed in the flock size are presented graphically in figure:V.e. The birds fed on fully ripe grains mainly from the fallen plants and sometimes on the grains found on the harvested ground. As the grains did not mature uniformly in different plots, the birds shifted their feeding from one plot to another having fallen paddy. Thus, in the case of the Blue Rock Pigeon the total number of invading days extended to twenty-four days. When the birds started visiting the cultivation, seven plots had fully ripened grains of which three had fallen plants. In one plot harvest was already over so that there were grains of paddy on the ground. The birds were never seen feeding from erect plants.

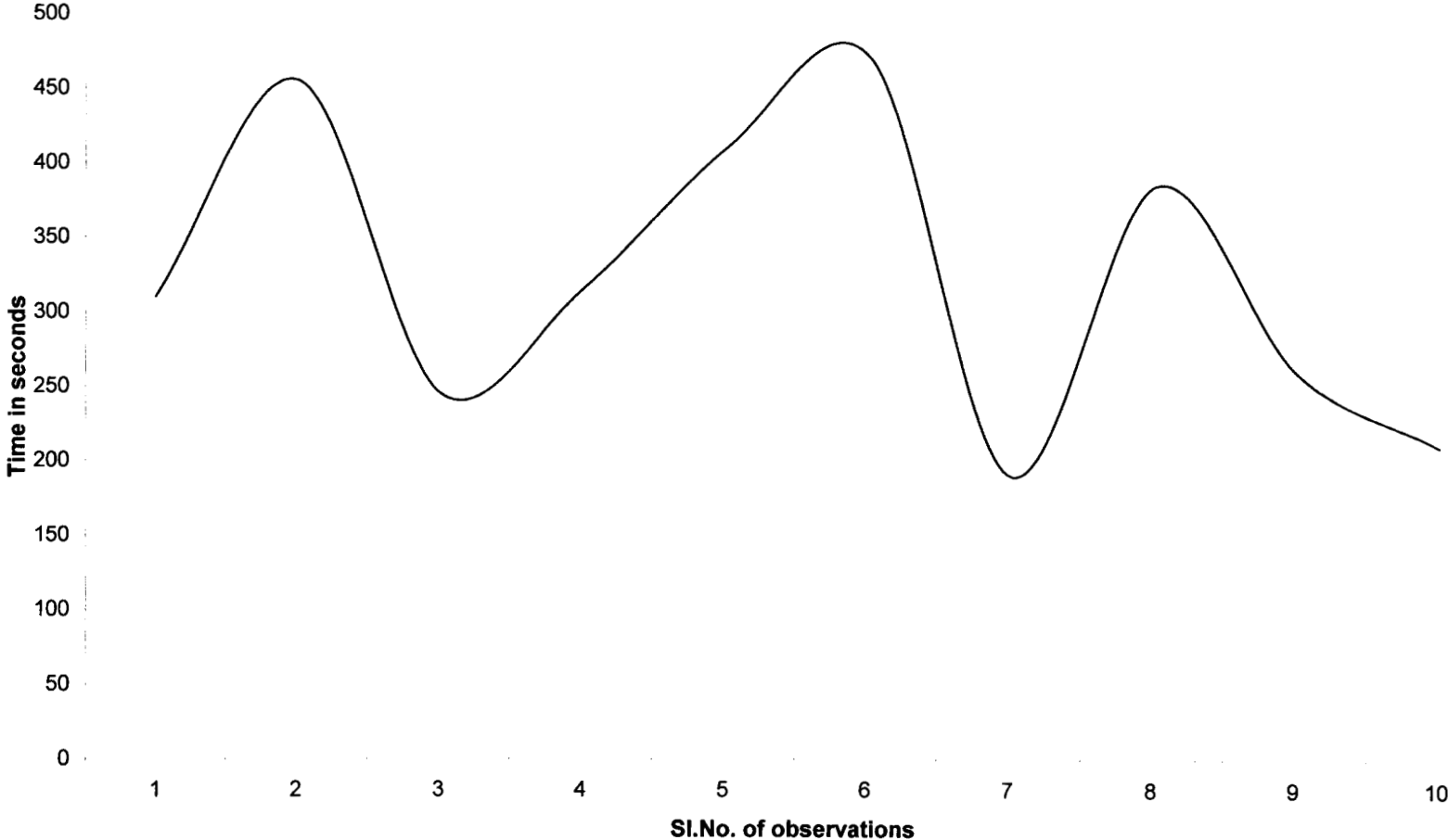
Small groups of 3-6 birds dropped into the field and formed large feeding groups. As the number increased the birds covered most of the field

Figure: V.e. - Variation in the flock size of the Bluerock Pigeon at Cherruppa



47

Figure: V.f. - Variation in the duration of feeding visits of the Blue Rock Pigeon



10

where fallen grains were available. To know the average time spent by the birds for each feeding visit, 10 birds were observed, one at a time and found that feeding time ranged between 3 min.10 sec. and 7min. 50 sec. with a mean 5 min.25 sec. \pm S.D. 1 min.38 sec. (Figure: V. f). After each feeding visit the birds left the field in the same movements and routes, which they had used to reach the field. The frequency of feeding bouts was observed for five consecutive days. Intense feeding was observed between 07.30 hr - 09.30 hr in the morning and 15.30 hr -17.30 hr in the evening. During mid day there was very little feeding and the birds rested on the tall coconut trees around the field or flew over the feeding ground in small groups. Very little feeding was observed between 11.30 hr-15.30 hr. This observation is tabulated and presented graphically in Figure:V. g.

After landing in the field, the foraging birds plucked the grains from the earheads or pecked them from the ground. The grains were swallowed with the husks. Each bird fed from an earhead for 0.5 to 3 minutes and shifted to the neighbouring one .The number of grains consumed / minute / bird was observed in ten birds and it varied between 14 and 32 with mean = $23.4 \pm$ S.D.5.347grains / minute. This is presented graphically in Figure V. h.

The foraging birds moved very slowly on the ground searching for the grains in harvested grounds. Feeding started from the peripheral areas and proceeded towards the interior areas of the field. At intervals of 3-7 min. small

Fig. V.g. - Variation in the frequency of feeding visits of the Blue Rock Pigeon

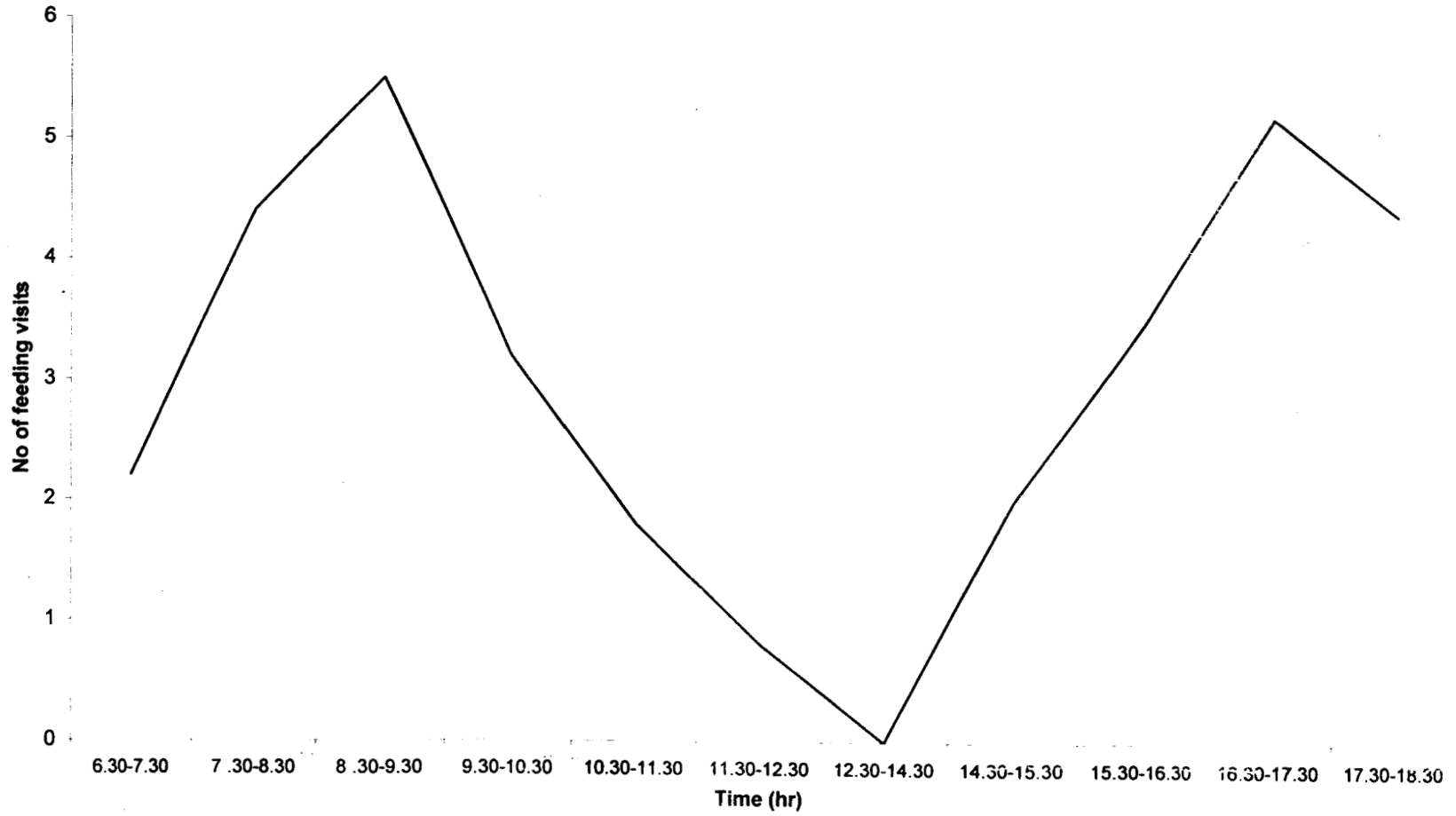
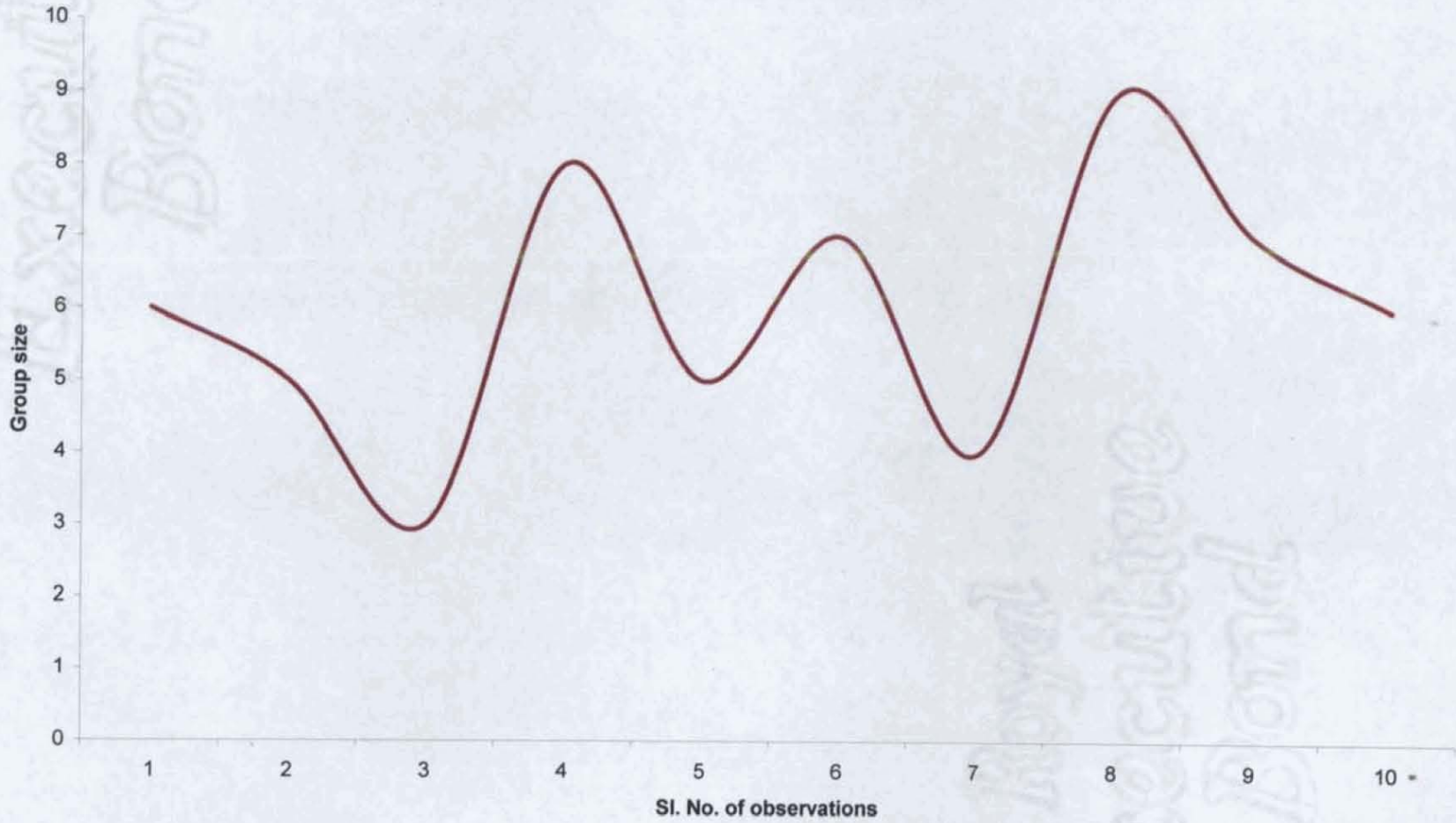


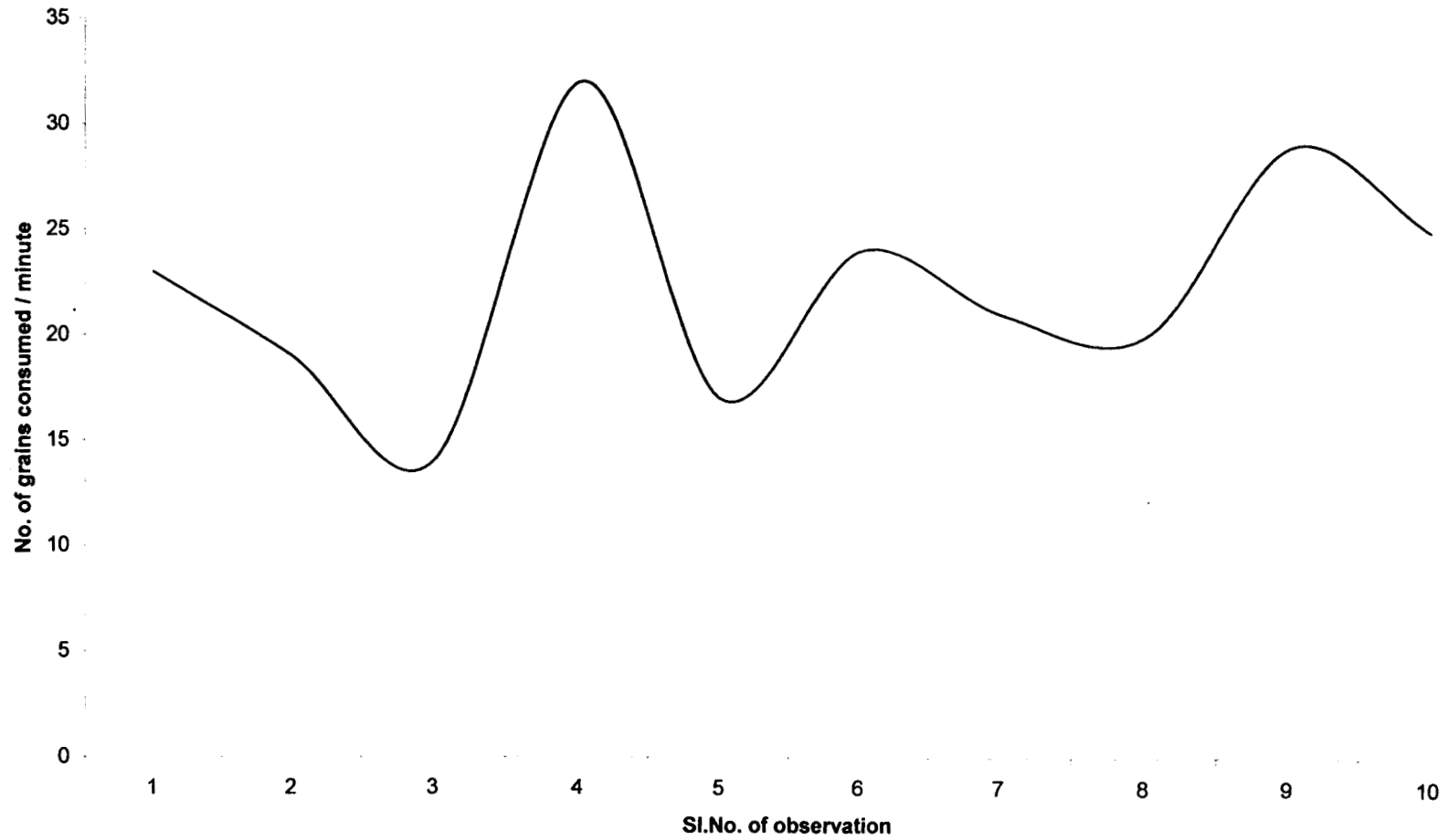
Figure: V.i. - Variation in the group size of the Blue Rock Pегion left the field at intervals



499 (50)

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Figure: V.h. - Variation in the rate of feeding in the Blue Rock Pigeon



groups of birds, size ranging from 3 to 9, with mean = $6 \pm$ S.D. 1.73., flew towards the nearby or distant sources of water. This observation is presented graphically in figure: V.i. These birds returned to the field after 3 -14 min. and repeated the same pattern of feeding.

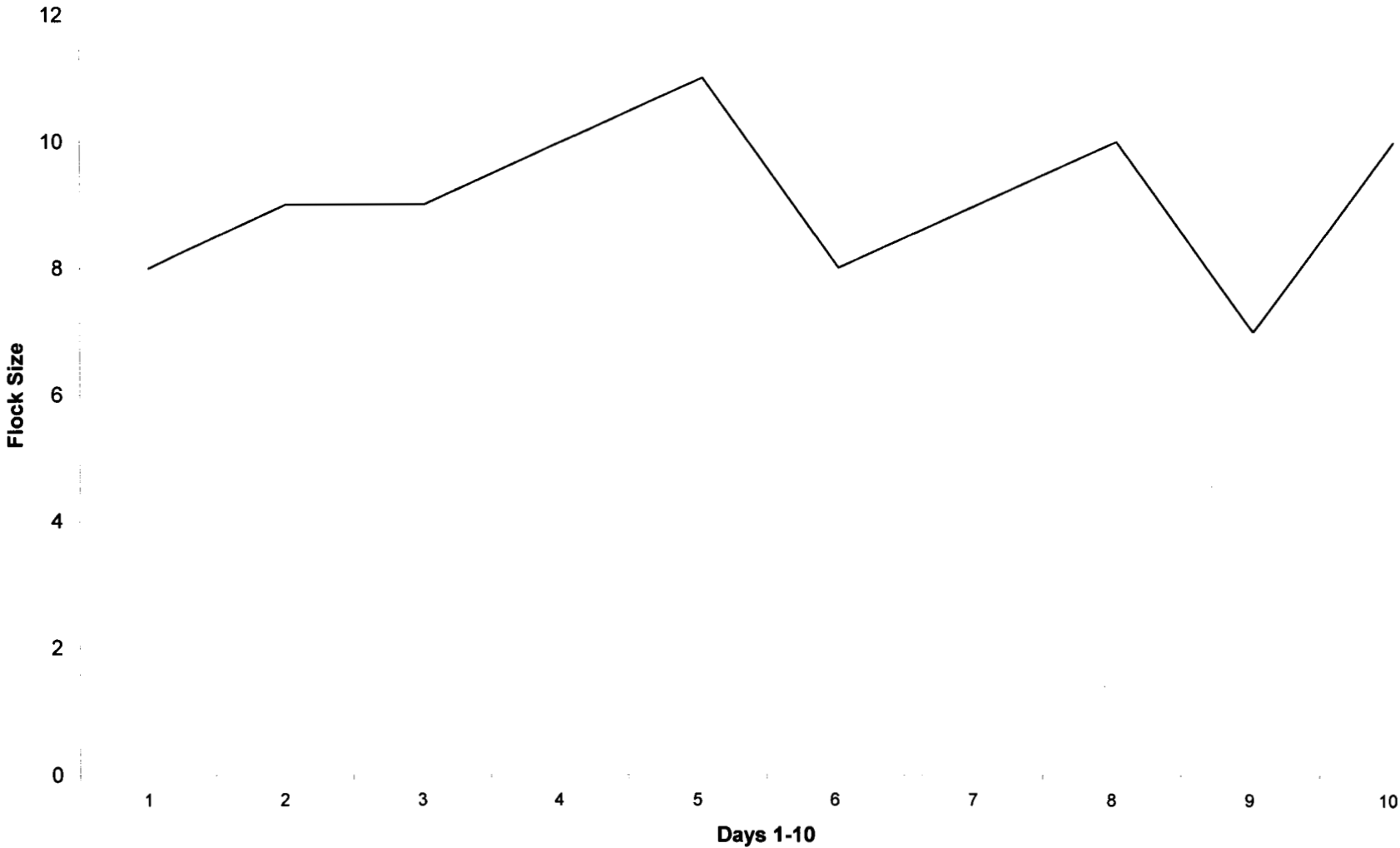
C. The Rose-ringed Parakeet (*Psittacula krameri*)

The feeding habits of the Rose-ringed Parakeet in the study site at Peruvayal are described in this section. Observations were conducted for 10 days from 2 - 11 February 1997. I visited the area frequently during the season to observe the presence of birds. The Rose-ringed Parakeets appeared in the field when the grains became ripe and continued to visit the cultivation frequently till the end of the harvest.

The size of the foraging flock of the Rose-ringed Parakeets ranged between 7 and 11 with mean 9.1 ± 1.14 S.D and density of population 0.83 birds / ha. The variation observed in the flock size is presented graphically in figure: V.j. No roosting site was observed in the immediate surroundings of the study site.

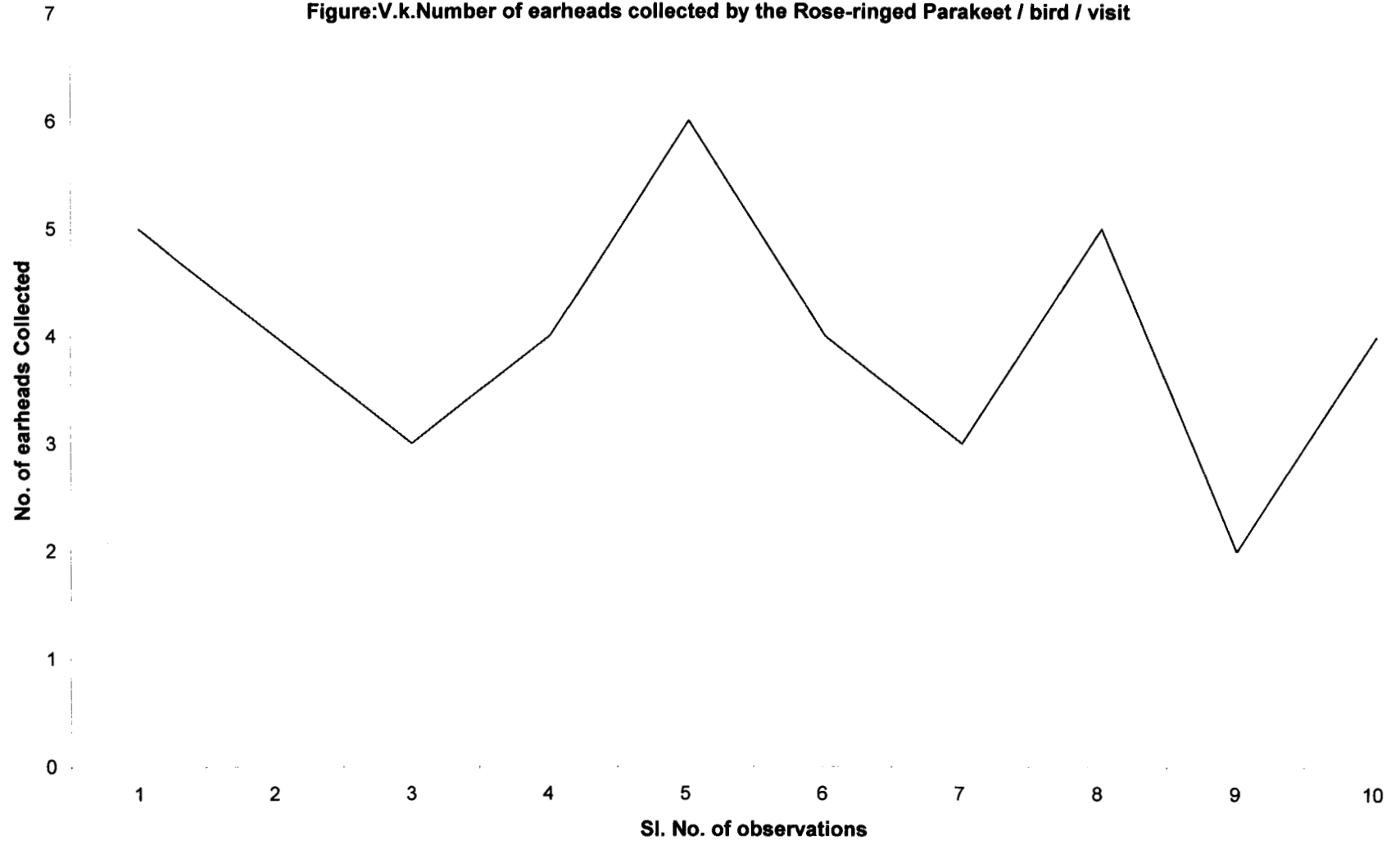
The flock of parakeets reached the paddy field from their roosting sites or from other feeding areas and hovered over the standing crops of ripe paddy. The birds collected earheads by cutting them at the base with beak and returned to their resting site. The birds collected the ripe earheads only, and I never saw the parakeets feeding on unripe paddy. The feeding area was so

Figure: V. j - Variation in the Flock size of the Rose-ringed Parakeet



33

Figure:V.k.Number of earheads collected by the Rose-ringed Parakeet / bird / visit



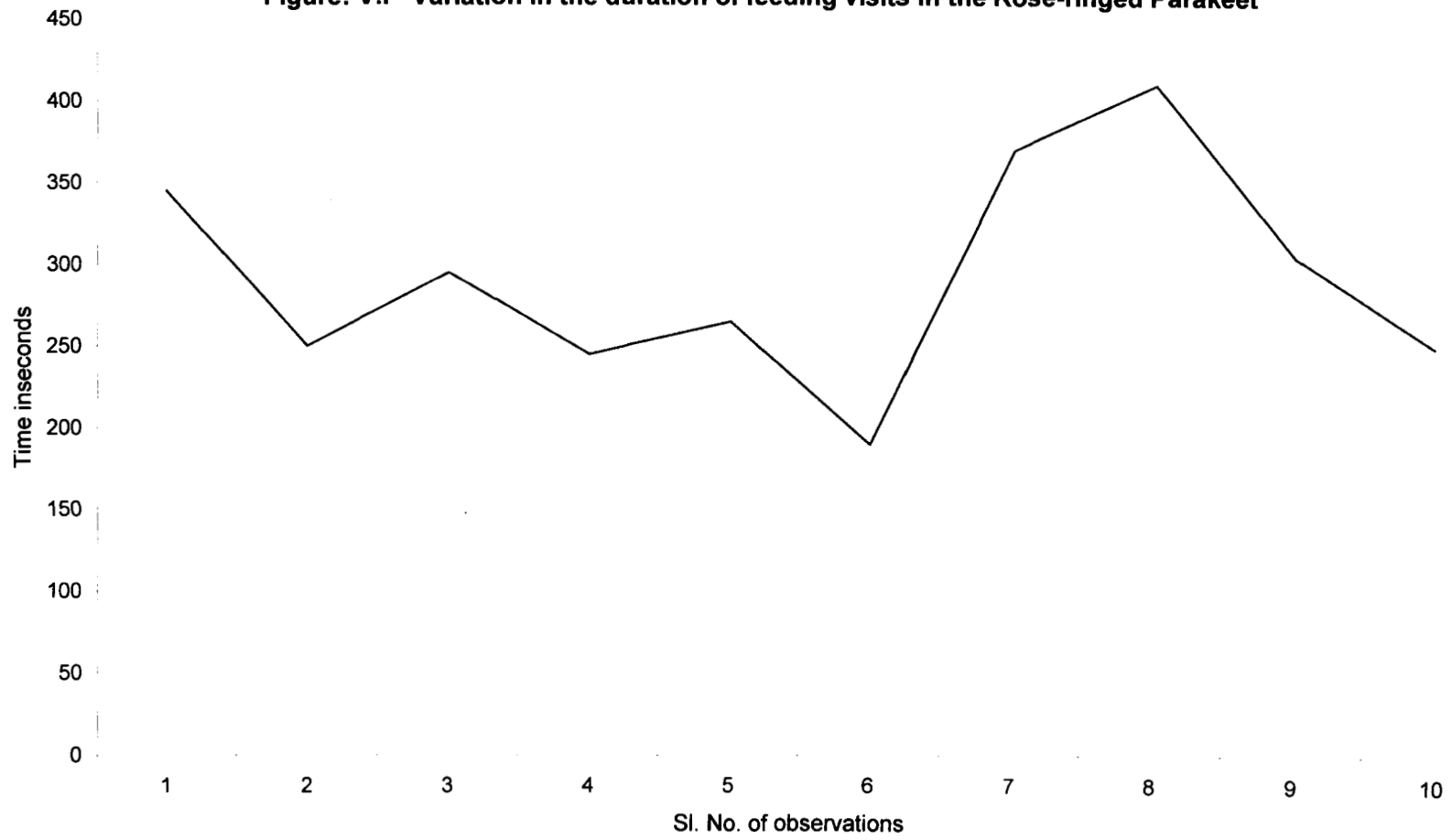
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limited that it appeared that the flock members could see each other. After collecting the earheads all the members of the flock together left the field to perch on the tall coconut trees in the surrounding areas of the field. During their return flight some of the birds dropped a few earheads. The earheads were kept under the toes and the parakeets then plucked, dehusked swallowed the grains one by one and dropped them after taking a few grains. The process of feeding was then repeated and was intervened by activities like preening, bill wiping etc. The birds wasted the grains when they carried the earheads to the perch and also by dropping them after consuming a few grains. Thus the crop loss included, the quantity of grains consumed by the birds or depredatory loss and the grains collected by the birds but not consumed or extra depredatory loss.

Ten birds were observed individually in different feeding visits to estimate the quantities of paddy destroyed (Figure:V.k.). One to four earheads were cut off by an individual Parakeet in each visit with mean $2.2 \pm \text{S.D. } 0.87$. The time spent for a visit was observed for ten visits and presented graphically in figure:V. l. The foraging birds spent 3 min. 10 sec. to 6 min.50 sec. for a collection trip with mean $4\text{min. } 52\text{sec.} \pm \text{S.D. } 1\text{min.}3 \text{ sec.}$

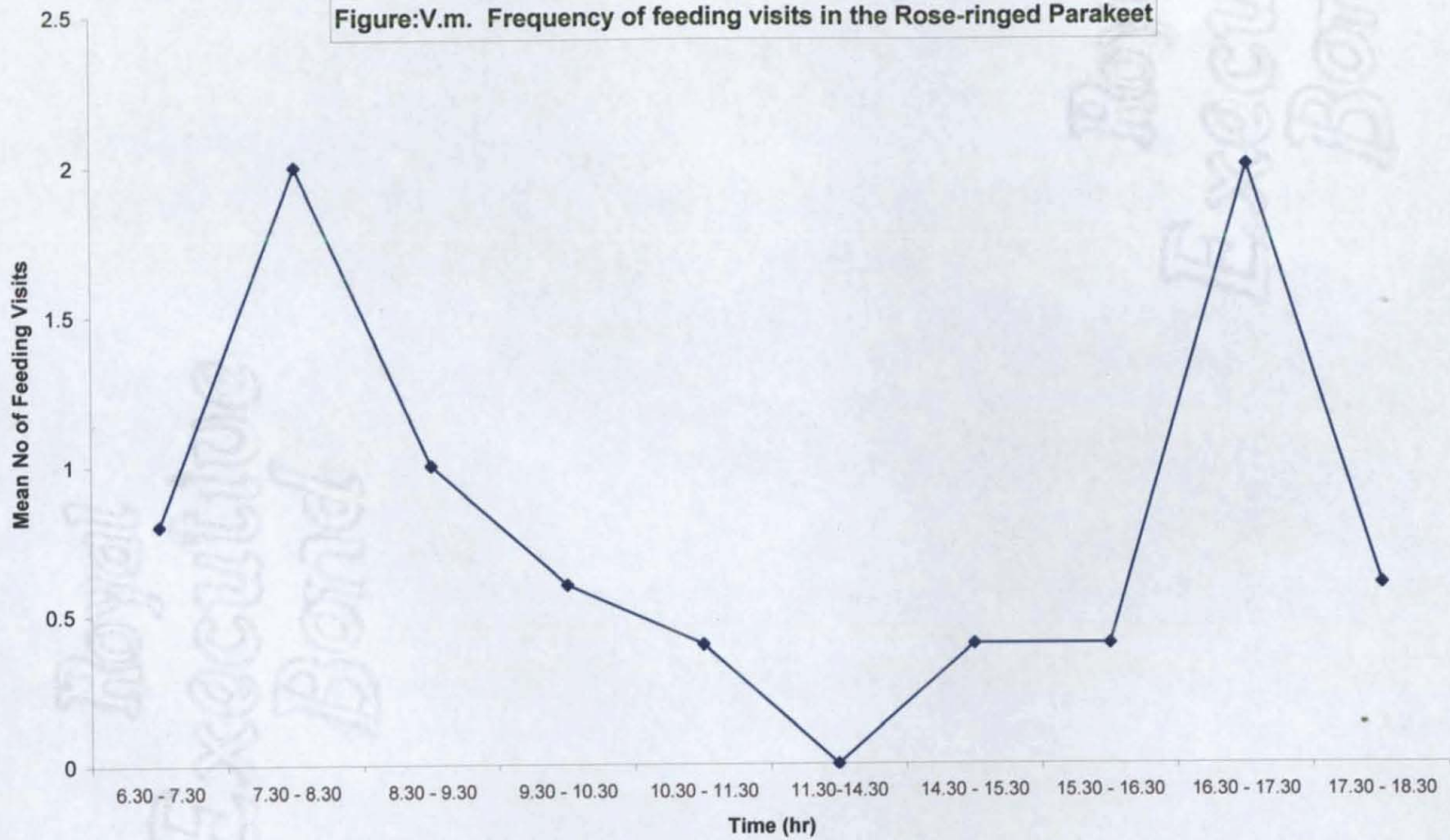
The birds collected the earheads in the morning and in the evening only and in the mid hours they were not seen in the field or in its immediate surroundings. Day long (06.30 to 18.30hr) observations for five days showed

Figure: V.I - Variation in the duration of feeding visits in the Rose-ringed Parakeet



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Figure:V.m. Frequency of feeding visits in the Rose-ringed Parakeet



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that the peak feeding times were 7.30 to 8.30 hr in the morning and 16.30 to 17.30 hr in the evening. The total number of feeding visits averaged 15 per day \pm S.D. 1.36. This observation is presented graphically in figure: V.m.

The foraging birds were not seen drinking water from the streams close to the feeding ground. As in the other study sites, paddy did not mature uniformly in all the plots, so that the birds shifted to the adjacent plots where ripe earheads were available and continued their attack in the study area for a period of 14 days.

Estimation of crop damage

An attempt is made to crudely estimate the damage to paddy on the basis of the field observation. The weight of paddy damaged or consumed / bird / day is assessed on the basis of the mean number of feeding visits / day, time taken for each visit and the feeding rate. It was found that one gram of paddy contained 31 grains and the mean number of grains / earhead was found to be 226. The expected average yield of paddy was 700 kilograms/hectare. Based on this the percentage of crop loss is predicted. The details of crop damage are shown in the table V.5, 6 and 7.

The weight of paddy consumed or damaged per bird per day (240.58 g) was the maximum in the Rose-ringed Parakeet, which included both depredatory and extra depredatory losses. This was minimum (14.59 g) in the Spotted Munia. The loss by the Spotted Munia at Kadakkattupara is found

negligible (0.01%). The Blue Rock Pigeon consumed about 0.45 percentage of the expected yield at Cherruppa and the Rose-ringed Parakeet caused 0.40 percentage damage in the field at Peruvayal.

Table:V.5: -Weight of paddy consumed or damaged by
the Spotted Munia and Blue Rock Pigeon

Bird	Mean No. of visits/day n	Mean time taken for a visit (min.) t	Feeding Rate, r	Number of grains consumed/damaged per day per bird N = ntr	Weight of Grains (g) Consumed or damaged/day/bird C = N/31
Spotted Munia	24.0	7.6	12.4grains in 5 minutes	452.35	14.59
Blue Rock Pigeon	32.4	5.4	23.4 grains/minute	4094.06	132.07

Table:V.6: Weight of paddy consumed or damaged by
the Rose-ringed Parakeet

Mean No. of visits/day n	Feeding Rate or number of earheads collected per visit r	Mean number of grains per earhead m	Number of grains consumed/damaged per day per bird N = nrm	Weight of Grains (g) Consumed or damaged/day/bird C = N/31
15	2.2	226	7458	240.58

Estimation of Damage Potential

The capacity of granivorous birds to inflict damage on standing crop depends on the weight of grains consumed or damaged per bird per day and

Table V.7: Estimated percentage of crop loss

Sl.No	Bird	Study area	Flock size s	No. of invading days in a season d	Estimated Yield(kg) W	Total loss (kg) L=C x s x d	Percentage of crop loss (L/W) x 100
1	Spotted Munia	Kadakkattupara	13.4	27	52,500	5.28	0.01
2	Blue Rock Pigeon	Cherruppa	29.4	24	21,000	93.19	0.45
3	Rose-ringed Parakeet	Peruvayal	9.1	14	7,700	30.65	0.40

Table V.8: Damage potential of the Spotted Munia, Blue Rock Pigeon and the Rose-ringed Parakeet in the study sites at Kadakkattupara, Cherruppa and Peruvayal respectively.

Bird	Weight of Grains (g) Consumed or damaged/day/bird C	No. of invading days in a season d	Individual damage potential(g) D = C x d
Spotted Munia	14.59	27	393.93
Blue Rock Pigeon	132.07	24	3169.68
Rose-ringed Parakeet	240.58	14	3368.12

the number of invading days in a season. Based on the above observations, the damage potential of the Spotted Munia, Blue Rock Pigeon and the Rose-ringed Parakeet was determined. (Table V. 8). The damage potential of an individual bird was highest in the Rose-ringed Parakeet and lowest in the Spotted Munia.

**ECOLOGICAL STUDIES ON CERTAIN SPECIES OF
GRANIVOROUS BIRDS IN MALABAR**

*Thesis submitted to the University of Calicut
for the Degree of
Doctor of Philosophy
in Zoology*

By

THOMAS A. T.

Department of Zoology,
University of Calicut.

March 2006

CHAPTER VI

STUDIES ON CAPTIVE BIRDS

The food preference of the three species of grain feeding birds observed in the study areas; the Spotted Munia, the Blue Rock Pigeon and the Rose-ringed Parakeet, was studied in captivity. The food preference of the White-backed Munia was studied earlier (Thomas, unpublished). Wild birds recently trapped in the field were acclimatized in the laboratory for one week and then fed with equal quantities of five different types of grains for ten days. A control set was maintained for each species. Based on the captivity study, the preference order to different types of grains, and the correlation between body weight and weight of food consumed / gram body weight of the bird, for each species were determined. The details of the study on captive birds are described in this chapter.

A. Food Preference

1. Spotted Munia

A sample of 12 birds was trapped from the wild and the study was conducted with the grains of Italian Millet, Common Millet, Ragi and Paddy and the seeds of the grass, *Sporobolus diander*. The wild birds were first subjected to acclimatization and then ten of them were selected for the experimental studies. Before the test the birds were weighed and the mean weight was found to be 13.12 g. These were divided into the experimental (E) and the

control (C) groups of five each.

The study was conducted during the period, 20th to 29th December 1997. The total weight of each food item consumed daily for ten days, by each group was determined and the results obtained were tabulated, consolidated to get the following values,

(1)The total weight of food items consumed by each group for ten days. (Table VI. I and figure: VI. a).

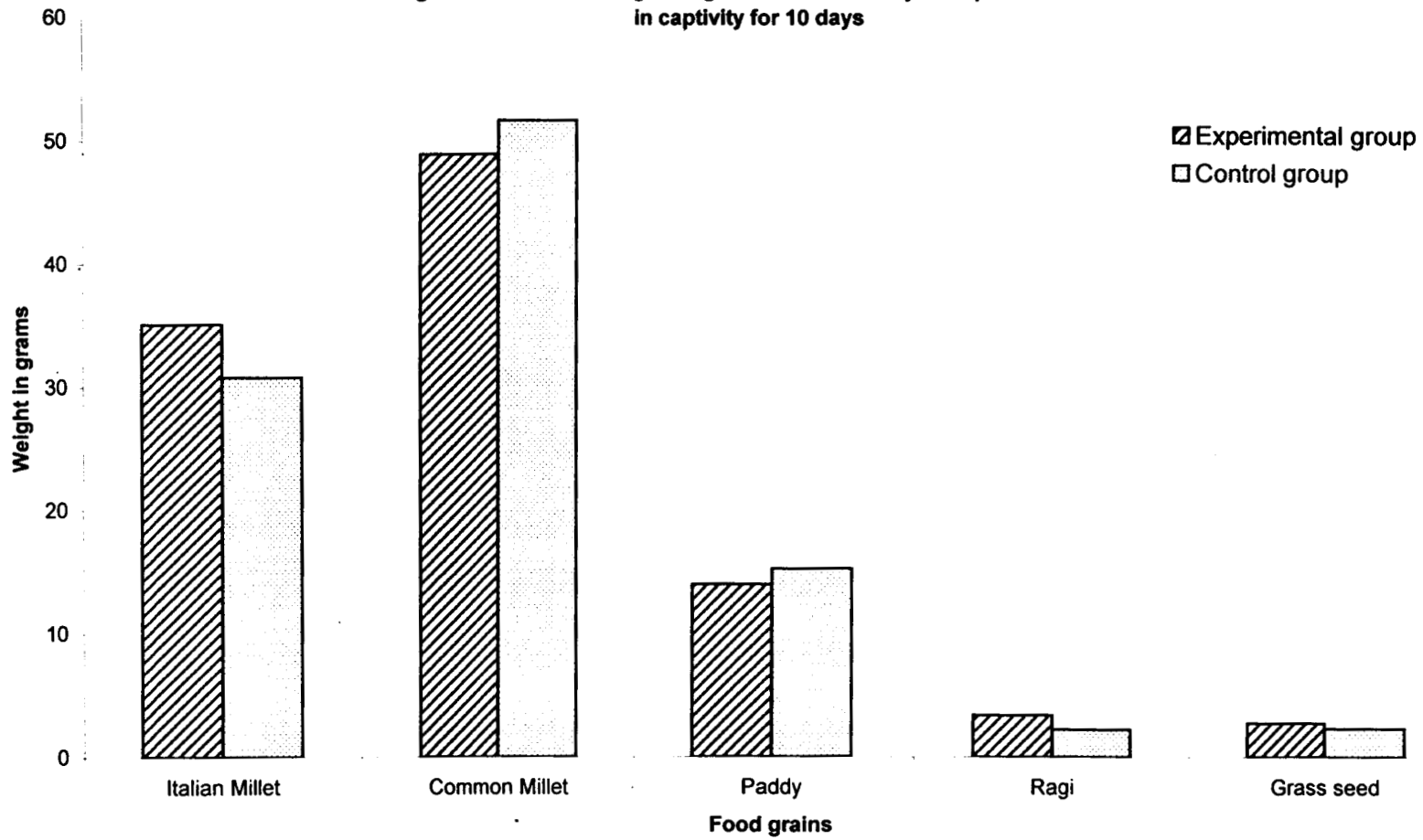
(2)The mean weight of the total quantity grains consumed by a Spotted Munia / day, \bar{X}_1 and \bar{X}_2 , for the experimental and control groups respectively. (Table VI. 2 and figure: VI. b).

(3)The mean weight of each food item consumed / bird / day for the experiment, control and also for both the groups combined.(Table VI. 3).

(4)The percentage of each food item consumed by each group for ten days (figure: VI. c).

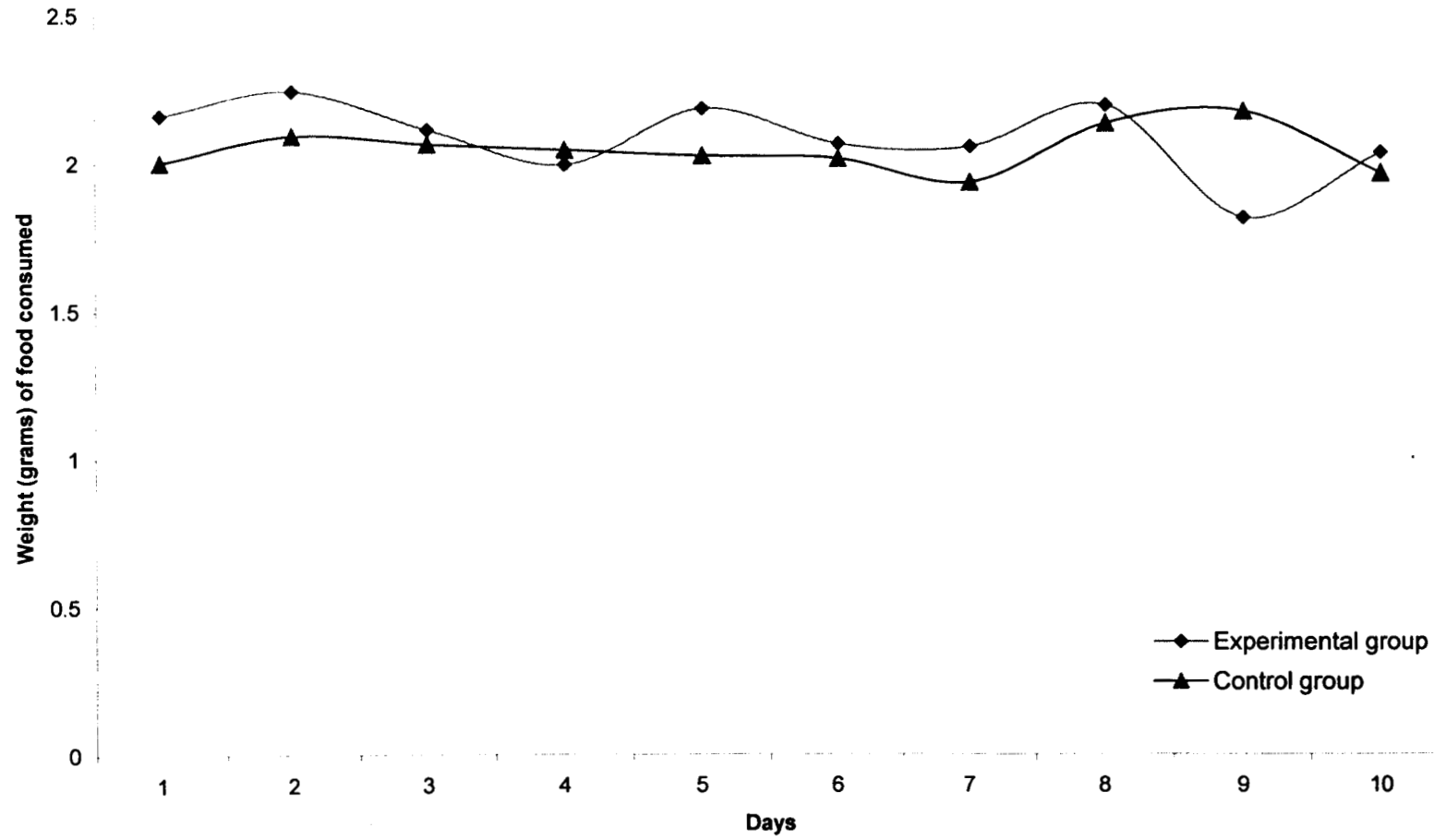
It was observed that, the experimental and the control groups consumed 103.92g and 102.00 g grains, respectively for ten days. On average, birds in the (E) group consumed 10.39g / day and the (C) group consumed 10.20g / day. In the 'E' group a bird consumed 2.08g (\bar{X}_1) and a 'C' group bird consumed 2.04g. (\bar{X}_2) of grains per day. Then, the difference between the mean weights of grains consumed / bird / day, \bar{X}_1 and \bar{X}_2 was tested by the

Figure: VI .a. - Total weight of grains consumed by the Spotted Munia in captivity for 10 days



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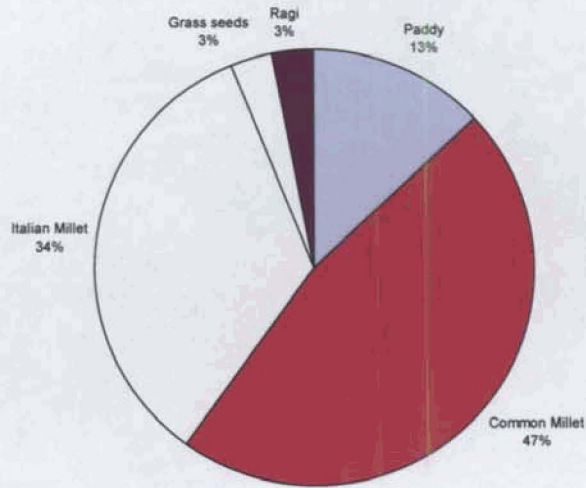
Figure: VI.b. Mean weight of food grains consumed by the Spotted Munia / day / bird



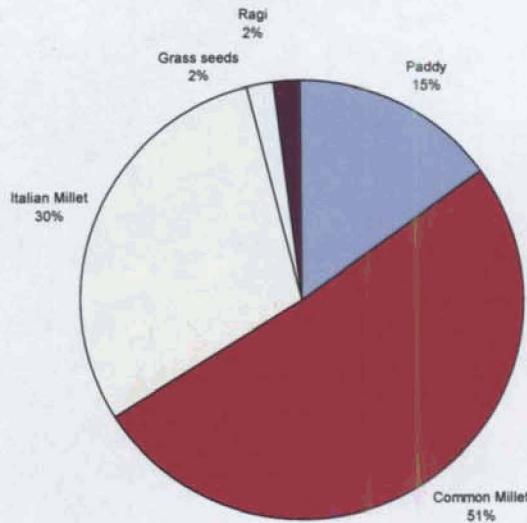
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Figure:VI.c. Food diversity of the Spotted Munia in captivity

a. Experimental group



b. Control group



t -test and found that the difference was insignificant.

The difference between the combined means of each food item consumed by a Spotted Munia / day was tested statistically by the ANOVA, and found that there was significant difference between the quantities of different food grains consumed by the Spotted Munia.

Table VI.1: - Total weight of food grains consumed by the Spotted Munia in captivity.

Group	Food items consumed (weight in grams)					Total
	Italian Millet	Common Millet	Paddy	Ragi	Grass seeds	
Experiment (E) n=5	35.06	48.82	13.93	3.37	2.74	103.92
Control(C) n=5	30.74	51.55	15.20	2.20	2.31	102.00

E - Experiment. C- Control

Table VI. 2: Mean weight (g) of the grains consumed by a Spotted Munia / day

Days \ Group	Mean weight in grams of daily total consumption										Mean
	1	2	3	4	5	6	7	8	9	10	
E	2.16	2.24	2.11	1.99	2.18	2.06	2.05	2.19	1.81	2.03	2.08
C	2.00	2.09	2.06	2.04	2.02	2.01	1.93	2.13	2.17	1.96	2.04

Table:VI.3: Mean weight of different food grains consumed by a Spotted Munia / day

Group	Mean weights (gs) of different food grains consumed /day /bird					Total
	Italian Millet	Common Millet	Paddy	Ragi	Grass seeds	
Experiment (E) n=5	0.70	0.98	0.28	0.07	0.05	2.08
Control(C) n=5	0.62	1.03	0.30	0.04	0.05	2.04
Mean of 'E' & 'C' combined	0.66	1.01	0.29	0.06	0.05	2.07

After the test feeding, the mean body weight of the birds was found to be 13.2 g, i.e., no significant difference in the body weight occurred during the study period.

The results of captivity study on the Spotted Munia, indicated the preference order to the grains supplied in the order;

Common Millet > Italian Millet > Paddy > Ragi > Grass Seeds.

2. Blue Rock Pigeon

The study was conducted from 16th to 25th January 1998. As in the previous experiment, twelve wild birds were acclimatized in the laboratory and tested for a period of 10 days. During this time they were fed with the grains of Italian Millet, Common Millet, Wheat, Paddy and Ragi. Then ten birds were

selected, weighed and divided into the experimental (E) and control (C) groups. Each group was supplied daily with 100 g of each food item and the weight of grains consumed was estimated as before to get the following Values;

(1)The total weight of food items consumed by each group for ten days.

(Table VI. 4 and figure: VI. d).

(2)The mean weight of the total quantity of grains consumed by a Blue Rock Pigeon / day, \bar{X}_1 and \bar{X}_2 , for the experimental and control groups respectively. (Table VI.5 and figure: VI.e).

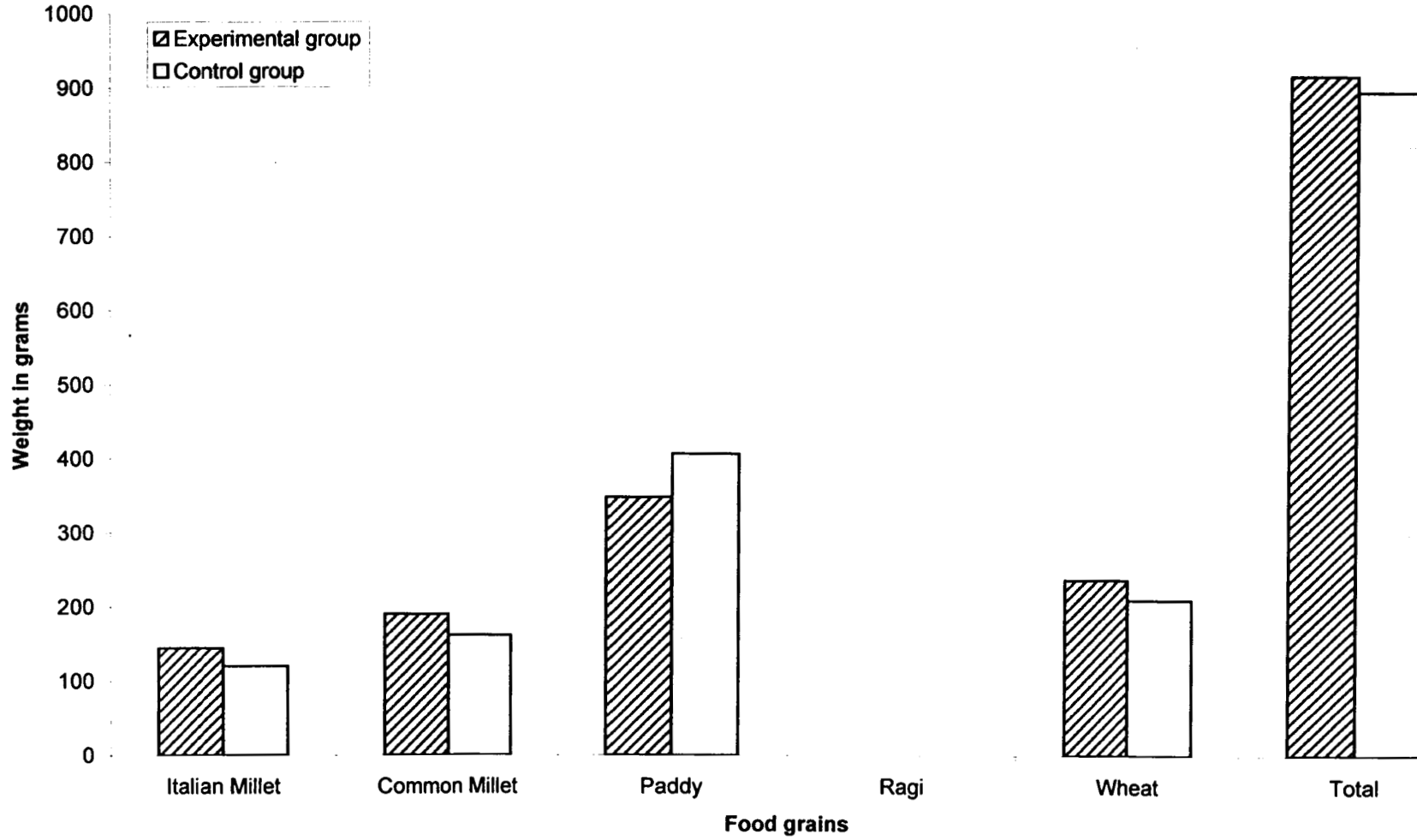
(3)The mean weight of each food item consumed/bird / day for the experiment, control and also for the combined group (Table VI.6)

(4)The percentage of each food item consumed by each group for ten days (figure: VI. f).

It was observed that, the experimental and the control groups consumed 918.23g and 896.77g grains, respectively. A Blue Rock Pigeon in the experiment set consumed an average of 18.40 g grains per day and in the control set the average consumption was 17.94 g. The *t* - test indicated that the difference between the mean weights is insignificant.

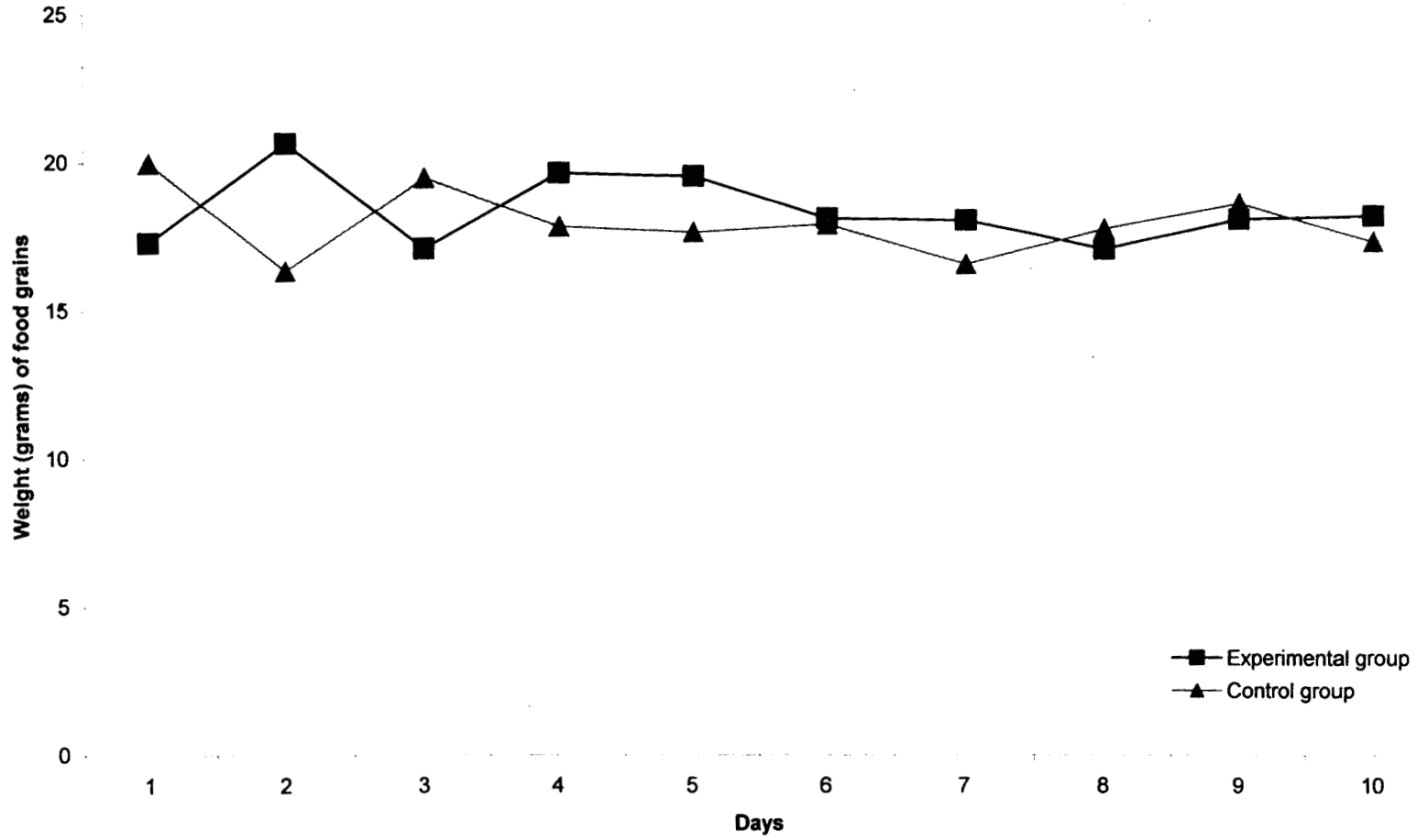
The difference between the combined mean weight of each food item consumed by a Blue Rock Pigeon / day was tested statistically by the ANOVA, and found that difference was significant.

Figure:VI.d. - Total weight of food grains consumed by the Blue Rock Pigeon



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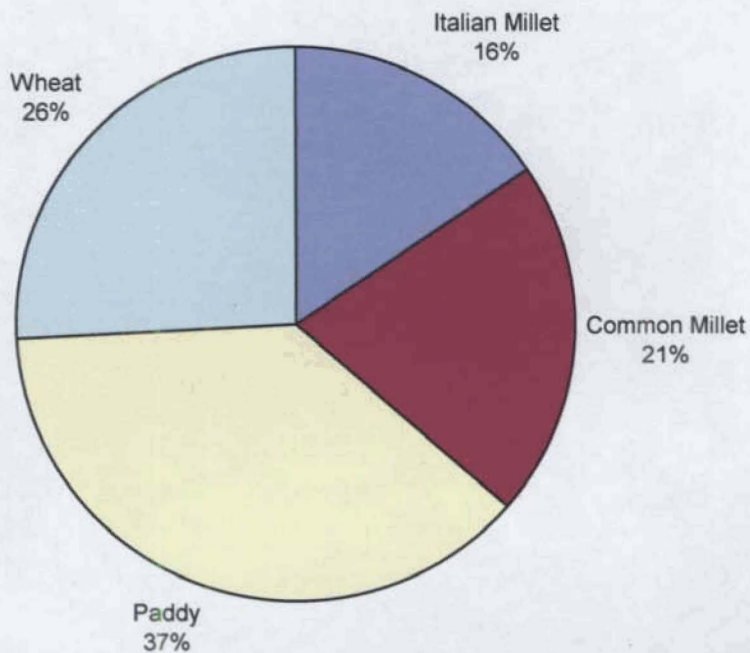
Figure: VI.e. Mean weight of food grains consumed by the Blue Rock Pigeon / day / bird



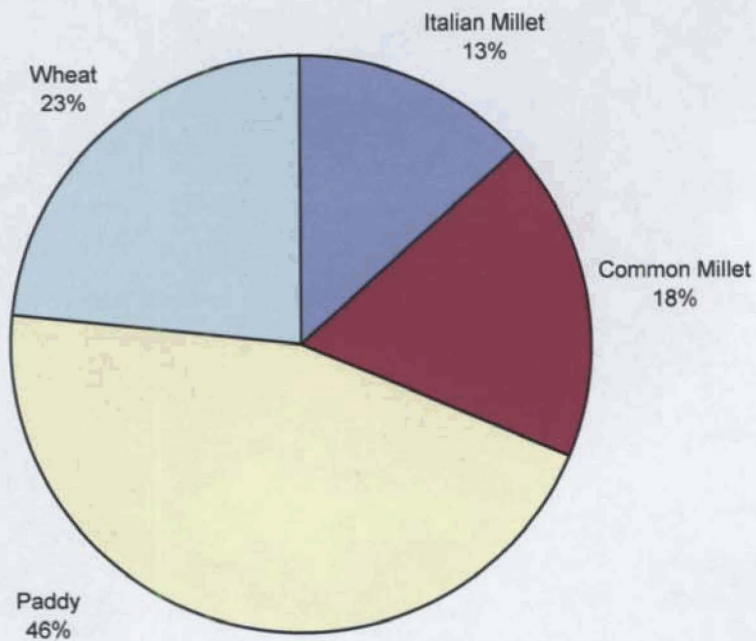
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Figure: VI.f. – Food diversity of the Blue Rock Pigeon in captivity

a. Experimental group



b. Control group



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Table.VI.4: Total weight (g) of food grains consumed by the Blue Rock Pigeon in captivity for ten days.

Group	Weight (g) of food grains					Total
	Italian Millet	Common Millet	Paddy	Ragi	Wheat	
E	144.06	189.98	347.56	0	236.67	918.23
C	119.78	160.95	406.32	0	209.72	896.77

E –Experimental. C –Control

Table VI. 5: Mean weight (g) of the total quantity of grains consumed per day per Blue Rock Pigeon in captivity.

Days Group	Mean weight in grams of daily total consumption										Mean
	1	2	3	4	5	6	7	8	9	10	
E	17.29	20.64	17.07	19.63	19.53	18.10	18.04	17.07	18.09	18.21	18.40
C	19.98	16.34	19.46	17.82	17.63	17.90	16.56	17.75	18.63	17.34	17.94

The result obtained suggested that the Blue Rock Pigeon showed maximum preference to the grains of Paddy and its consumption is slightly higher in the control group. The difference between mean weight of food consumed / bird / day in the E & C group was tested and found to be statistically insignificant. The difference between the combined averages of

individual items consumed / bird / day was tested by the ANOVA and found statistically significant.

Table VI.6: Mean weight of different food grains consumed by a Blue Rock Pigeon / day

Group	Weight (g) of food grains					Total
	Italian Millet	Common Millet	Paddy	Ragi	Wheat	
E	2.88	3.80	6.95	0	4.73	18.36
C	2.40	3.22	8.13	0	4.19	17.94
Mean of 'E' & 'C' combined	2.64	3.51	7.54	0	4.46	18.15

Based on the results of ANOVA of mean weight of each food item consumed by a Blue Rock Pigeon / day and the percentage of each item consumed in captivity the food preference was determined as follows,

Paddy > Wheat > Common Millet > Italian Millet.

The mean weight of the birds before and after the test was 244.018g. and 244.28 g respectively. Apparently test feeding had not affected the birds adversely.

3. Rose-ringed Parakeet

The preference to grains in Rose-ringed parakeet was tested in captivity for 10 days from 3rd to 12th march 1997. After acclimatization, the birds were weighed and the average weight was found to be 105.60g. They were then divided into the experimental and control group, each consisting of five birds. They were then held in separate cages, as before. For test feeding the birds were supplied with 50 grams each of the grains of Paddy, Wheat, Common Millet and Ragi. As in the previous cases, the data collected were tabulated to obtain the following values;

(1) The total weight of food items consumed by each group for ten days.

(Table VI. 7 and figure: VI. g).

(2)The mean weight of the grains consumed by a Rose-ringed parakeet / day, \bar{X}_1 and \bar{X}_2 , for the experimental and control groups respectively.

(Table VI.8 and figure: VI. h).

(3)The mean weight of each food item consumed by a Rose-ringed parakeet / day for the experiment, control and also for both the groups combined (Table VI. 9).

(4)The percentage of each food item consumed by each group for ten days (figure: VI. i).

The total weight of the food grains consumed during the test period, by the experimental and control groups were 435.07g and 437.25g respectively. The mean weight of food grains consumed / bird / day was 8.70g and 8.75g for

Figure: VI.g. - Total weight of food grains consumed by the Rose-ringed Parakeet

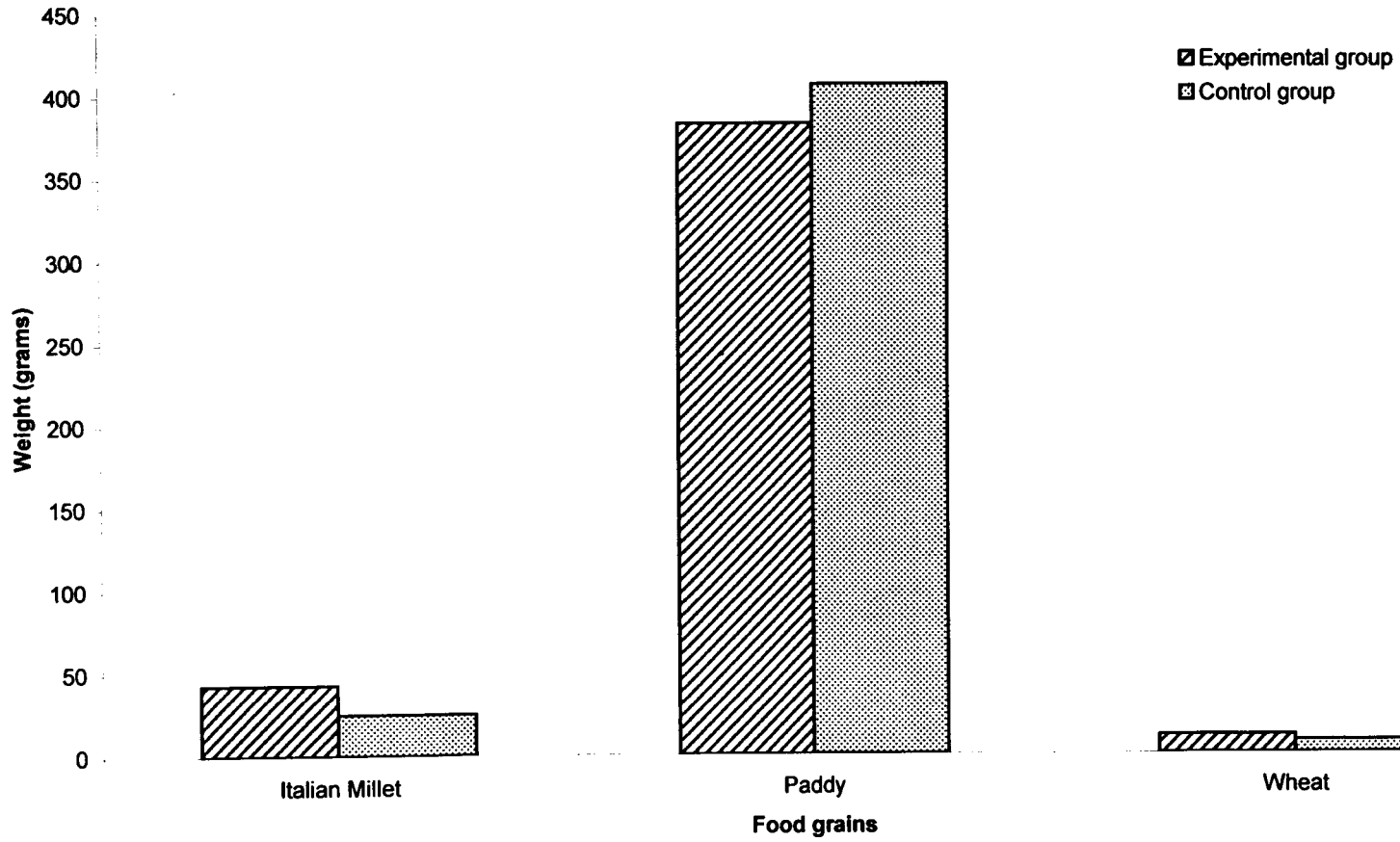


Figure: VI.h. Mean weight of food grains consumed by the Rose-ringed Parakeet /day /bird

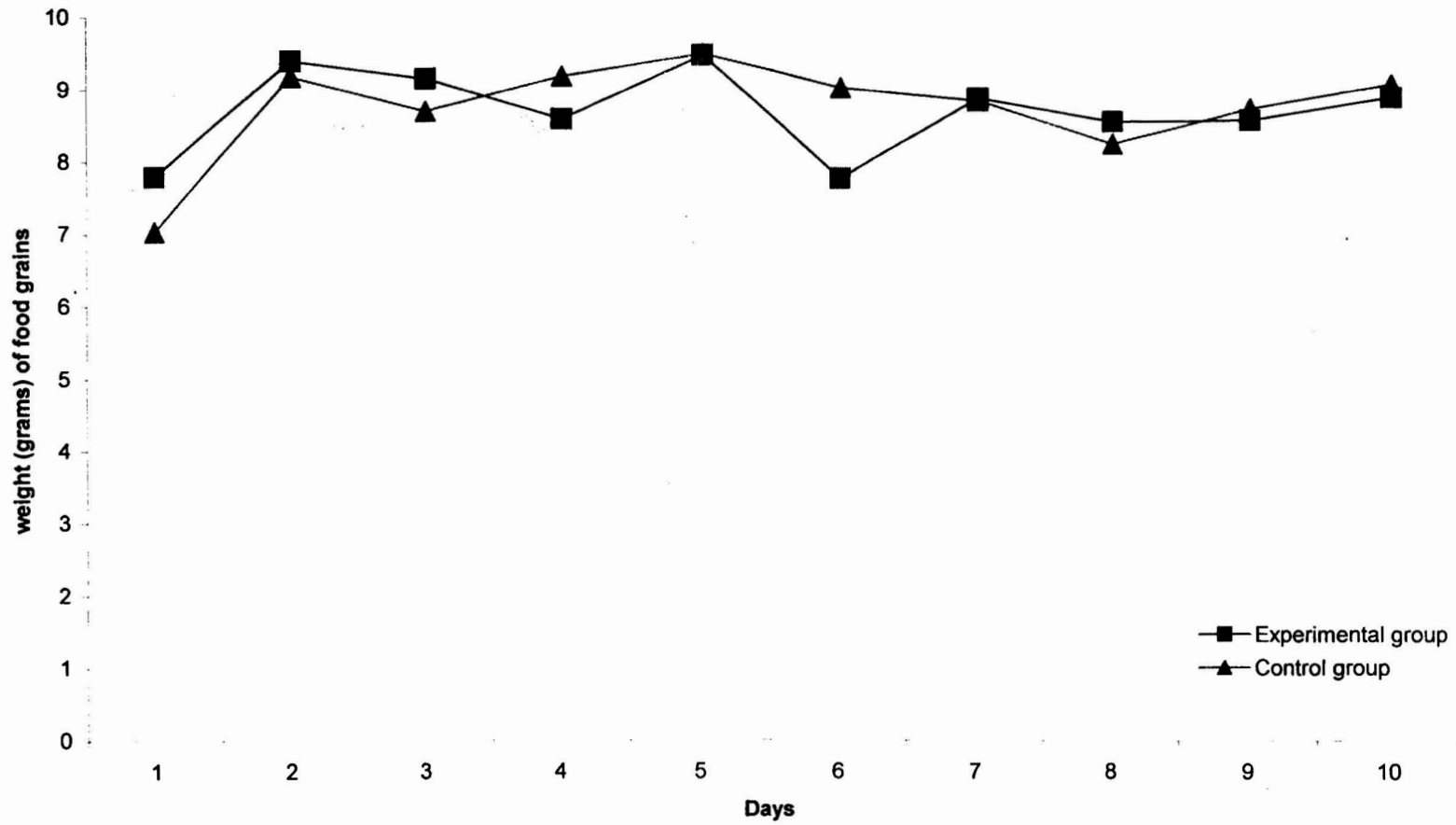
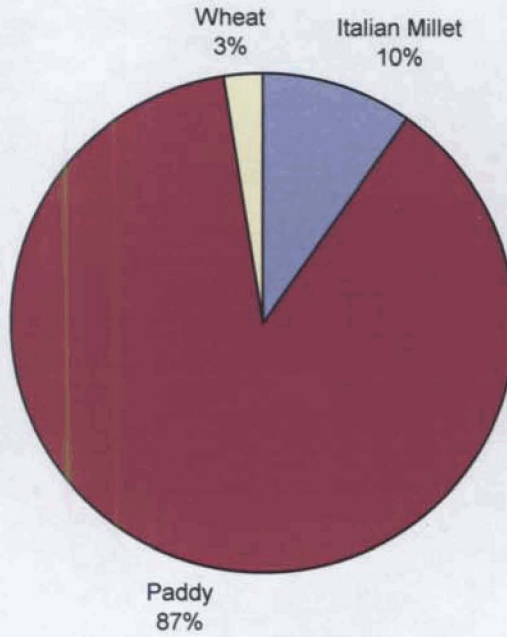
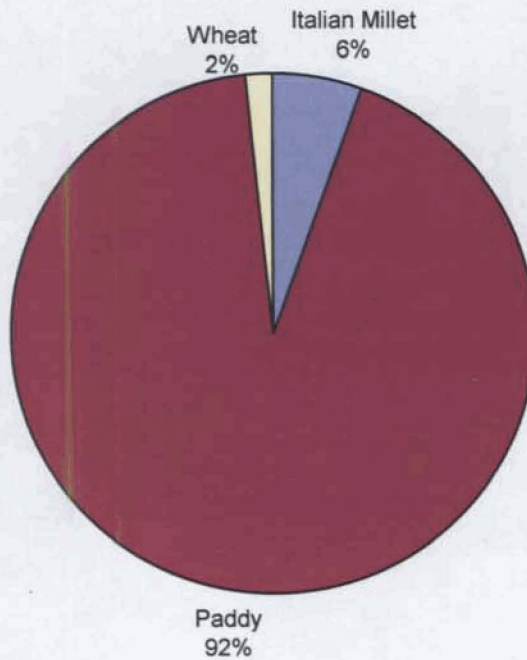


Figure: VI.i. Food diversity of the Rose-ringed Parakeet in captivity

a. Experimental group



b. Control group



the experimental and control groups respectively. There was no significant difference between the average weights of food consumed by the experimental and control groups. The difference between the combined mean weights of each food item consumed a Rose-ringed parakeet / day was tested statistically by the

Table VI.7 -Total weight (g) of different types of food grains consumed by the Rose-ringed Parakeet in captivity for ten days

Group	<i>Food grains supplied</i>					Total
	Italian Millet	Common Millet	Paddy	Wheat	Ragi	
Experimental (E) n=5	42.76	0	381.41	10.90	0	436.07
Control (C) n=5	24.79	0	405.04	7.42	0	437.25

Table: VI.8 - Mean weight (g) of grains consumed by a Rose-ringed parakeet / day

Days Groups	<i>Mean weight in grams of daily total consumption</i>										Mean
	1	2	3	4	5	6	7	8	9	10	
E	7.79	9.39	9.14	8.58	9.46	7.76	8.87	8.55	8.58	8.90	8.70
C	7.03	9.17	8.69	9.17	9.48	9.01	8.84	8.24	8.74	9.08	8.75

Table VI. 9: Mean weights of each food item consumed
by a Rose-ringed Parakeet / day

Groups	<i>Mean weights (gs) of different food grains consumed /day /bird</i>					Total
	Italian Millet	Common Millet	Paddy	Wheat	Ragi	
Experimental (E) n=5	0.86	0	7.63	0.22	0	8.71
Control (C) n=5	0.50	0	8.10	0.15	0	8.75
Mean of 'E' & 'C' combined	0.68	0	7.87	0.19	0	8.74

ANOVA, and it was found to be significant. The Rose-ringed Parakeets showed the maximum preference to the grains of Paddy and its consumption was slightly higher in the control group. The birds showed no preference to the grains of Common Millet and Ragi. The preference order to the grains supplied was determined by as before and it was as follows;

Paddy > Italian Millet > Wheat.

The weight of the birds after the test was 105.81g and the difference was found to be statistically insignificant. Hence, test- feeding had no adverse effect on the body weight of the birds.

B. Correlation between body-weight and food consumed / gram body weight

Study on the extent of correlation between body weight (X) and the actual weight (g) of food consumed / gram body weight (Y) in the above three species and that in the Whitebacked Munia (Thomas,unpublished) is described in this section. The percentage of water content in the grains and grass seeds provided is shown in the table VI.10. In this part of the study the weight of food items consumed by the experimental and control groups were considered together to get the mean weight of food consumed / gram body weight. By subtracting the weight of water content, the actual weight of each food item consumed /gram bodyweight in each case was determined and is shown in the table VI.11.

Table VI.10.-Water content (%) in the food items provided

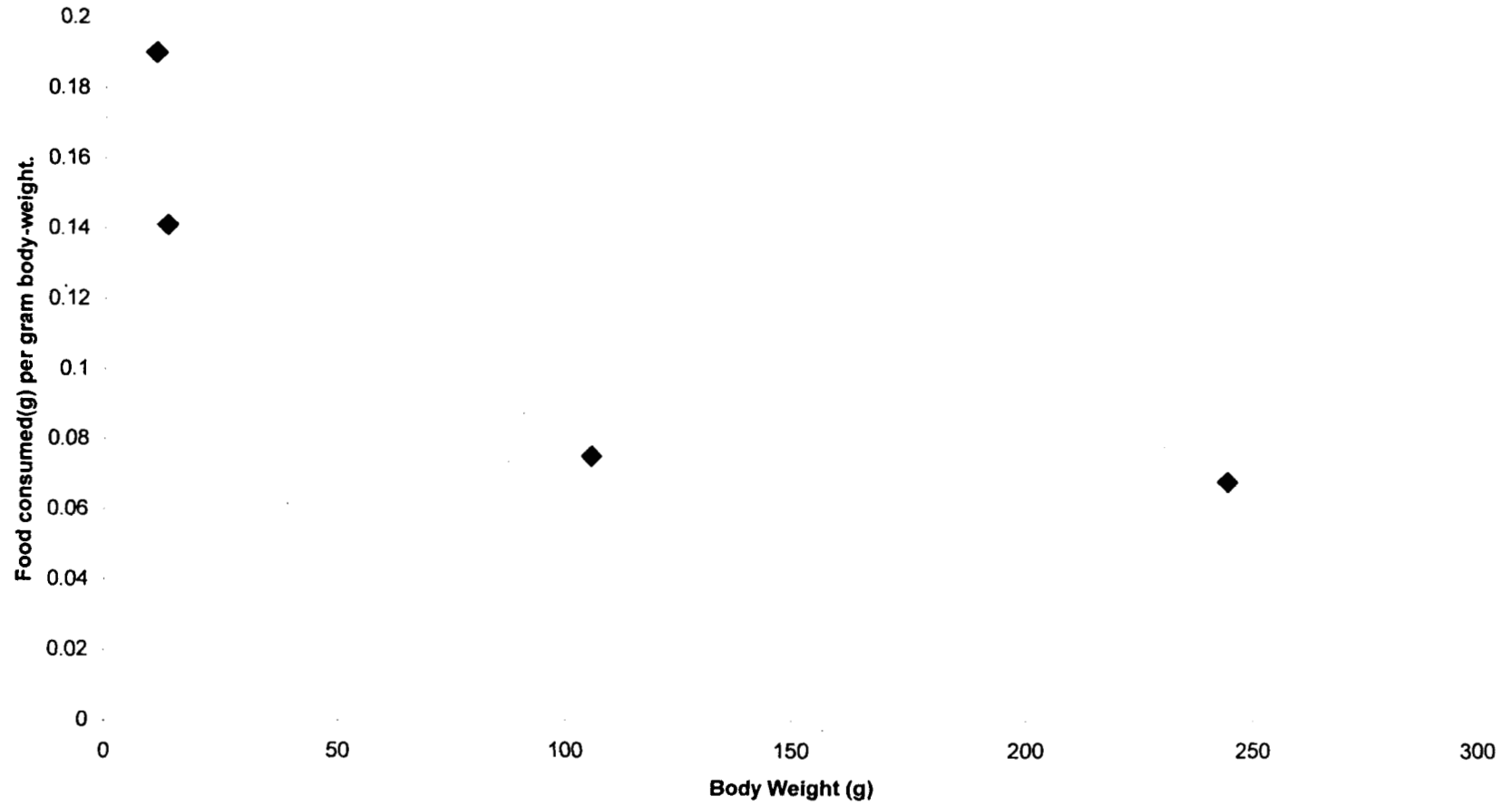
Sl.no.	Food grain	% of Water content
1	Itallian Millet	8.6
2	Common Millet	10.4
3	Paddy	8.8
4	Ragi	8.2
5	Wheat	6.0
6	Grass seeds	6.4

Table:VI.11 Actual weight (g) of food grains consumed g / body weight of the birds in captivity.

Bird	Actual weight (g)of food consumed in captivity for ten days by ten birds						Body – weight (g) (X)	Weight of food g / g body weight (Y)
	Itallian Millet	Common Millet	Paddy	Wheat	Ragi	Grass-seeds		
Spotted Munia	60.14	89.93	26.57	---	5.11	4.73	13.16	0.141
Blue Rock Pigeon	241.15	314.43	687.51	419.61	0	---	244.45	0.068
Rose-ringed Parakeet	61.74	0	717.24	16.28	0	--	105.75	0.075
White-backed Munia	--	--	--	--	--	--	10.76	0.19

The correlation between the two variables X and Y is presented graphically in figure VI.j. The extent of correlation is expressed numerically by calculating the value of the co-efficient of correlation ' r ' and is found to be – 0.77. Both the correlation graph and the coefficient of correlation indicate a high degree of negative correlation between the two variables. It indicates that in grain feeding birds, as body weight increases there is a corresponding decrease in the weight of food consumed/g body weight or vice versa.

Figure:VI.j. - Correlation between the body-weight(X) and the weight of food consumed per g body weight(Y) in the granivorous birds



Regression analysis

The regression analysis is made on the basis of P_{xy} , (the average of the joint variation of the two variables X and Y), \bar{X} and S_x the mean and standard deviation of body weight respectively, and \bar{Y} and S_y the mean and standard deviation of weight of food (g) / g body weight respectively. The regression equation, X on Y is written on the assumption that, as the X value changes there is a corresponding change in the Y value. Similarly, the equation Y on X is written on the assumption that as Y value changes, there is a corresponding change in the X value.

The regression equation X on Y is,

$$X - \bar{X} = \frac{P_{xy}}{S_y^2}(Y - \bar{Y})$$

where, $\bar{X} = 93.46$, $P_{xy} = -16.11$, $S_y^2 = 0.003$ and $\bar{Y} = 0.12$

Therefore,

$$X - 93.46 = \frac{-0.16.11}{0.003}(Y - 0.12)$$

Using this, the most probable value of X (body weight) can be predicted for a given value of Y (weight of food consumed/ gram body weight)

Similarly, the regression equation Y on X is,

$$Y - \bar{Y} = \frac{P_{xy}}{S_x^2}(X - \bar{X})$$

where, $\bar{Y} = 0.12$, $S_x^2 = 95.06$

i.e.,

$$Y - 0.12 = \frac{-16.11}{95.06}(X - 93.46)$$

This can be used to predict the probable Y value for a given X value.

**ECOLOGICAL STUDIES ON CERTAIN SPECIES OF
GRANIVOROUS BIRDS IN MALABAR**

*Thesis submitted to the University of Calicut
for the Degree of
Doctor of Philosophy
in Zoology*

By

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Department of Zoology,
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March 2006

CHAPTER VII

DISSCUSSION, SUMMARY AND CONCLUSION

My observations and experiments on the food and feeding habits of the Spotted Munia, the Blue Rock Pigeon and the Rose-ringed Parakeet in the districts of Calicut and Malappuram are finally discussed in this chapter. The study plots were Ummalathoor, Pookkad, Cherruppa, Koolimadu, Peruvayal and Ulliyeri in Calicut district and Kadakkattupara in Malappuram district. The physiographic features and agricultural practices followed in the selected sites were typical of the paddy fields of Malabar.

Occurrence of Granivorous birds

The occurrence of birds feeding on the paddy grains was studied in the paddy fields selected in Calicut and Malappuram districts. The total number of species of granivorous birds, their occurrence ratio, flock size and density of population in the study sites were determined. The species richness or the total number of species (Mc Naughton and Wolf 1970) of granivorous birds recorded from all the localities studied was only six.

Individually, the field at Kadakkattupara recorded the maximum number of granivorous species of birds with 5 species and the fields at Koolimadu and Ulliyeri recorded the minimum with 2 species. Four species of granivorous birds were recorded from the study sites at, Ummalathoor, Pookkad and Cherruppa

and only 3 species were recorded from the study site at Peruvayal. In a recent ecological study, Cheruvath (2004) reported 12 species of granivorous birds in the '*Kaipad*' wetlands of Kannur district of Kerala, where a traditional system of farming is practiced. In my study, the notable reduction in the total number of species of granivorous birds and the variation observed in their local distribution may be due to factors like smaller size of the field, proximity to other habitats, changes in the adjoining vegetation, number of cultivating seasons, application of lethal and non lethal techniques to deter birds, human interferences and capture of birds. In the study area, the fields were of limited in size and paddy was the only main crop. Population studies on the avifauna conducted in other parts of India suggest that decrease in the cultivating area and absence of other cultivations affect the occurrence and population size of birds adversely. In a study on the harvesting paddy fields in Andhra Pradesh, Srinivasulu et al. (1994) recorded 42 species of birds and Dhindsa et al. (1988), made similar observations in an intensively cultivated area at Ludhiana, and reported a total of 68 species. This is probably because in any other state of India the fields are vast and hold a variety of crops whereas in my study area the fields were of limited in size and paddy was the only main crop. The occurrence of comparatively higher number of species of granivorous birds at Kadakkattupara may be due to the larger area of the field and the absence of vehicular traffic and minimum movement of man in and around the field. The decrease in the total number of granivorous birds in the study sites agrees with

the suggestion that communities in stable environment such as the tropical rain forests have higher species diversities than communities that are subjected to periodic perturbances by man or nature (Odum 1971). The observations on the distribution of granivorous species of birds in the study areas suggest that the paddy fields and their environs form a monotonous habitat subjected to periodic perturbances by man, and hold only a very few species of birds which can exploit the limited resources.

The study indicated that the Blue Rock Pigeon, which was observed in all of the study sites was the most common granivorous bird and the Spotted Munia occurred in only two of the sites was the least common one in this part of Malabar. The Rose- ringed Parakeet and the White-backed Munia, with occurrence ratios, 5/7 and 4/7 respectively, were somewhat common in the region. The occurrence ratio of the Blossom-headed Parakeet and the Spotted Dove (3/5) indicated that the bird was not a common sight in the paddy fields of this region.

In this study, the total number of species of the granivorous birds, their flock size and density of population were comparatively poor. In the study sites the flock sizes of the Spotted Munia, the Blue Rock Pigeon and the Rose-ringed Parakeet ranged between, 6.8-13.4, 4.8 -29.4 and 6.6-10.6 respectively. According to Cheruvath (2000), the population size of the munias reached upto 900 in the paddy fields of North Malabar where traditional system of farming

was followed. In a study on the community structure of birds in the paddy fields of Andhra Pradesh, Srinivasulu et al. (1994), reported the flock sizes of the Spotted Munia and the Blue Rock Pigeon as 31 to 59 and 21 to 79 respectively. In my observation, though the Rose-ringed Parakeet was recorded in five out of the seven study sites, its mean flock size was very low, ranged between 7 and 11 birds. Chakravarthy (1998) found the flock size of the Rose-ringed Parakeet varying between 20 to 45 in Karnataka. In Kota, Rajasthan, it is reported that, the flock size of the Rose-ringed Parakeet reaching upto a maximum of 130 bird (Anon 1999). The comparatively smaller flock size of the species may be due to the large-scale capturing of the birds for commercial purposes. According to information collected from local farmers, earlier, the Rose-ringed Parakeet was more common and numerous in paddy fields in all the study areas. Thus, in general, the study revealed that the total number and the flock size of the granivorous species were comparatively smaller. This seems to be due to various factors like the comparatively smaller area of the field, absence of crop diversity due to monoculture, environmental problems due to the addition of fertilizer and application pesticides, habitat degradation and change in the agriculture practices as suggested by Siriwardene et al. (2000). Many paddy fields in the neighbouring areas of the study sites were subjected to severe degradation or modification by intensive cultivation year after year, and by filling and dredging the fields for residential or industrial purposes. This trend in the conversion of paddy fields for other purposes

causes shrinking in the area of paddy cultivation in Kerala. These environmental factors and the large scale capture of birds like the Rose-ringed Parakeets , appears to summate and cause a decline in the population size of the granivorous birds in the study areas . However, detailed and systematic investigation is required to confirm this.

Feeding habits

1. The Spotted Munia

The feeding habit of the Spotted Munia was observed in the paddy field at Kadakkattupara where its average flock size was around 14. The species is considered to be a pest of paddy from the nursery to the ripening stages (Parasharya et al. 2002) and reported to occur as flocks, sometimes numbering upto two hundred or more (Ali 1976). The Munias started feeding on paddy from its milky stage onwards and continued their attack till harvest. As paddy did not mature uniformly in all the plots in the field, grains in different stages of ripening were available simultaneously for more than one week. During this period, when milky and ripe paddies were available at the same time, the Munias fed in the plots holding paddy of the milky stage, suggesting that the species preferred the grains in that stage. The birds started feeding on the ripe grains only when those in the milky stage were not available. This adjustability to the food item at its different stages of ripening, assured the Munias a sure source of food for a long period of time. The Munias plucked, dehusked and

consumed the grains one by one after perching on the earheads. Thus, these birds got more time to feed but spent less energy for the foraging movements. An occasional grain dropped while dehusking was their only form of waste in feeding. The process of dehusking and extra depredatory loss appeared to increase the feeding time and expenditure of energy. The Spotted Munias and the White-backed Munias formed loose, opportunistic feeding gatherings in the study site. Both the species together used the adjoining banana plantation as a base to attack the paddy cultivation. They used the banana leaves as resting sites and escaped into the cover of the plantation when disturbed. Subramanya (1994) studied the importance of adjoining roosts for the Baya Weaverbird and the three species of munias (*Lonchura striata*, *L. punctulata*, and *L. malabarica*), in attacking the rice fields in Bangalore and found that these birds visited the rice fields in dense stands of reeds. According to that study the abundance of pests in a rice field decreased nonlinearly with increase in the distance of the feeding sites from the roost site. The White-backed Munias that I have studied earlier at Ulliyeri were using a mango tree close to the rice field as perch and inflicted considerable damage to the standing crop close to the perch (Thomas, unpublished). In the present study, the White-backed Munias of site 1 used a thicket of bamboo as their day roost. But in site 6 where there were no roosts nearby, the Munias left the field directly after each feeding session. In Cuddappah, Andhra Pradesh, the day roosts were used as bases for feeding operations and for coordinating the movements by the Baya

Weaverbirds (Mathew 1976).

2. The Blue Rock Pigeon

In my observation, the Blue Rock pigeon was the only granivorous bird common to all the study sites. The mean flock size of the Pigeons at Cherruppa field was 29.4. Throughout the period of my study there was not much fluctuation in the size in the flock size of the Pigeons. Sandhu and Sandhu (1998) also did not observe any significant fluctuation in the population sizes of the Blue Rock Pigeon during their period of study in the agroecosystems in Ludhiana.

Pigeons are primarily grain feeders (Murton et al 1963). But, based on his studies on domesticated pigeons (*Columba livia*), Brown (1969) found that pigeons prefer peas to grains and feed on grains, which is available for most of the year as a compromise to exploit the food available in the environment. In my observation, paddy was the major food item of the Pigeons and they fed on the ripe grains picked up, from the fallen earheads while moving slowly on the ground or on the discarded grains from the harvested ground. A foraging group started feeding from the peripheral parts of the field and slowly increased in number and spread to all parts of the ground. The Pigeons swallowed the grains without removing the husk. Perhaps this helps to increase the feeding efficiency and reduced the extra depredatory loss. Small groups of birds left and joined the foraging groups at intervals suggesting some form of association

between the members of the feeding flock. Mathew (1976) has observed similar activity in the Philippine Weaverbird.

3. The Rose-ringed Parakeet

The flock size of the Rose-ringed Parakeets in the paddy field at Peruvayal was around nine and it remained fairly constant during the course of my study. All the members of the foraging flock moved together as a unit. The Parakeets carry the earheads they cut from the field to the perching sites, eat a few grains and drop the rest. Thus, they wasted far more grains than they actually ate (Ali 1976). This habit of carrying the earheads to the perches minimizes the time spent in the feeding ground but definitely increases the crop loss and the energy required for feeding. The Rose-ringed Parakeet is regarded by many authors as the most serious avian pest on paddy in India (Ali and Ripley 1983 and Dhindsa 1993).

Comparison of the feeding habits

Paddy was the crop extensively cultivated in my study area, and when available, the main source of food for the three granivorous species of birds. These birds were nomadic groups in the neighbouring localities that migrate to the rice field at its yielding stage to feed on the grains of paddy. Granivorous birds shift their feeding grounds frequently (Weins and Johnston 1977) and feed in groups probably for the benefits of group feeding like avoidance of predators (Subramanya 1994) and the location of food resources. In the study

areas, different species of granivorous birds coexisted without conflict, probably because of the abundance of food materials. According to Lack (1954) different species may coexist in the abundance of food. Field observations indicated that paddy was their major food resource of the granivorous birds. In the study plot at Kadakkattupara, the Spotted Munia and the White-backed Munia formed a loose gathering and fed from the same area. This agrees with the observation that the granivorous assemblages overlap broadly in the use of food resources, as suggested by Rottenberry (1980), Pulliam (1985) and Dickman (1994). It appeared that the Munias required the adjoining vegetation of the field as a cover to escape and to use as a base for coordinating their foraging movements. But no such field condition was essential for the other two species for attacking the paddy cultivation. As the Munias fed on the grains of different stages of ripening, they appeared to be more adapted to the conditions of food than the other two species. This attribute enabled the Munias to attack paddy cultivation for a longer duration than the other two species. Observation on their feeding habits showed that these birds differed in their resource utilization pattern. The Munias fed on the grains after perching on the earhead and consumed the grains slowly with minimum extra depredatory loss. The Pigeons fed by moving on the ground and pecked and consumed the grains without de-husking so that there was no significant extra depredatory loss. The Parakeets cut the earheads and carry them to the perch, plucked the grains, de-husked and swallowed them. Thus the energy spent for foraging appeared to be higher

in the Parakeets. Among the three species studied, energetically and economically the Parakeets had the most wasteful way of feeding. As the Pigeons collected the grains without any waste and by spending the minimum energy, their feeding efficiency appeared to be much superior to that of the Rose-ringed Parakeet. As some extra depredatory loss of grains occurred in the case of the Munias also, they appeared to be more wasteful than the Pigeons.

The Munias , the Pigeons and the Parakeets observed in this study, fed in two distinct sessions; with slight variations in the peak hours of feeding. The foraging groups of the Munias and the Pigeons dropped in to the field in small groups and formed large groups there, whereas the Parakeets moved as a single flock. In the case of the Munias the total number of feeding visits averaged 24 per day, with a mean duration of 7.6 min for each visit. In the case of the Blue Rock Pigeon these values are 32 and 5.4 min respectively and in the Parakeets 15 and 5.4 min respectively. Thus, it appears that with respect to the total time spent in the field for feeding there was no significant difference between the Munias and the Pigeons. As the Pigeons fed more efficiently they consumed much higher quantity of food than the Munias and the Parakeets.

Damage potential and crop loss

The damage inflicted by the granivorous birds on paddy, depends on the diversity of the birds, the weight of grains consumed / day/ bird, the flock size

and the number of days of invasion for each species. Therefore an attempt was made in this study to assess the damage potential of the three species of granivorous birds on paddy cultivation, on the basis of their feeding habits.

The weight of crop loss inflicted in g / day/ bird was estimated as 14.59, 132.07, 240.58, for the Spotted Munia, the Blue Rock Pigeon and the Rose-ringed Parakeet respectively. The damage potential of a species at individual level is a function of the weight of grains consumed / day/ bird and the number of days of invasion, which varied with species. The estimated damage potentials were 393.93, 3169.68 and 3368.12 for the Spotted Munia, the Blue Rock Pigeon and the Rose-ringed Parakeet respectively. In this study, though the weight of grains consumed or damaged / day/ bird was much higher in the case of the Rose-ringed Parakeet. However, the total loss inflicted by the Parakeets was not comparatively very high because of their low flock size and comparatively short invading period. Therefore, these figures agree with the observation that the Rose-ringed Parakeet has the highest potential to inflict damage to paddy as suggested by Ali and Ripley (1983), Dhindsa et al. (1993) and Chakravarthy (1998). The percentage of crop loss inflicted by the Rose-ringed Parakeet was estimated to be only 0.40 and that in Blue-Rock Pigeon and the Spotted Munia were 0.45 and 0.01 respectively. However the Pigeons are reported to consume freshly sown paddy also (Parasharya et al. 2002). In the case of the Munias, the crop loss was insignificant when compared to the total yield. The crop loss incurred by these birds in the study area is found to

be much below the estimated average loss of 1.5 to 6% of paddy in Kerala by different birds (Parasharya et al. 2002). Therefore, this study supports the observation that there is always a tendency to overestimate the damage caused by birds (Weatherhead et al. 1982) and objective estimates are very important to know the magnitude of loss inflicted by birds (Dolbeer 1981).

Studies on captive birds

The food preference of the three species of granivorous birds was determined in captivity on the basis of the percentage of different kinds of grains consumed and by the analysis of variance between the average weights of grains consumed. In this study, the preference to grains among the three species of birds was in the following order:

a. The Spotted Munia:

Common Millet > Italian Millet > Paddy > Ragi > Grass seeds.

b. The Blue Rock Pigeon:

Paddy > Wheat > Common Millet > Italian Millet.

c. The Rose-ringed Parakeet:

Paddy > Italian Millet > Wheat .

The study shows that paddy was the most preferred grain for the Pigeons and the Parakeets and the millets to the Munias. In all the cases studied, there was no significant difference between the quantity of food

consumed by the experimental and the control groups. The continuous supply of water appeared to have no significant effect on the rate of feeding. Similarly the differences between the mean weights of the birds before and after the experiment were also found insignificant. These values suggested that, the experimental feeding had not affected body weight of birds adversely. In all the three cases studied, the quantity of grains consumed by each bird in the wild was much higher than that was consumed in captivity. This high rate of food consumption in the field was definitely to support the high metabolic rate in the wild for providing energy for flight and other activities.

Among the three species studied, only the Spotted Munia consumed from all the items provided in their diet. The pigeons consumed four and the parakeets fed only on three out of the five types of grains provided. The pigeons consumed the grains of paddy, wheat and millets, without much variation in their quantity, supporting the observation that pigeons compromise their diet to exploit the food available in the environment (Brown 1969). In the Rose-ringed Parakeet the grains of paddy and Italian Millet constituted about 90% of the total quantity of food consumed. This species is considered to be a consistent pest of wheat in the fields of Rajasthan and Gujarat (Parasharya et al. 2002). Hence it may be suggested that though the Rose-ringed Parakeets appeared rather rigid in their food choice behaviour, they compromised their diet according to availability in the environment. Though millets are not cultivated in the study areas or in its neighboring localities, the Munias

preferred these grains to paddy and the Pigeons and the Parakeets also consumed some quantity of millets. Thus in this study, all the three species, compromised their food choice and explored the availability of the food resources to varying extents. The Parakeets took only the Italian Millet in addition to paddy and wheat and were the most rigid species with respect to food preference, among the three species examined. In an earlier study I had found that the White-backed Munias preferred millets in captivity. Munias appear to prefer millets, which have smooth seed coat and are thus easier to handle. From the results obtained from the tests conducted in captivity, it appears that, all the three granivorous species of birds studied are plastic in their food requirement and opportunistic in their feeding to varying extents. Paddy might not have been a naturally preferred food item of these granivorous birds in the wild and they became associated with this with the evolution of agricultural practices of man and the degradation of natural habitats. When the habitat is changed or modified the organism has to adapt or perish. It appears that the granivorous birds are pre-adapted to the changes in habitat by virtue of their opportunistic feeding and according to Clark et al. (1994), in agricultural areas these birds harvest energy more efficiently than in their natural habitats. Thus the results support the conclusion that granivorous birds make extraordinary success when agricultural ecosystems are available to them (Weins and Johnston 1977) and the suggestion that opportunism looks like a necessary feeding strategy for granivorous birds (Perez and Bulla 2000).

In my experiments on captive feeding, the mean body weight (g) was around 13 g, 244 g and 108 g for the Spotted Munia, Blue Rock Pigeon and Rose-ringed Parakeet respectively. The actual weight of food consumed per day was around 2 g in the Spotted Munia, 18 g in the Blue-Rock Pigeon and 9 g in the Rose-ringed Parakeet. The order of magnitude of the bodyweight of the birds was, Blue Rock Pigeon > Rose-ringed Parakeet > Spotted Munia and that of the actual weight of food consumed per gram weight of the bird was; Spotted Munia > Rose-ringed Parakeet > Blue Rock Pigeon. This shows that as bodyweight (X) increases the actual weight of food consumed per gram weight (Y) decreases or vice versa or negative correlation between the two variables. This agrees with the observation of Van Tyne and Berger (1971) that the smaller birds consume larger quantities of food in relation to their body mass. The correlation graph and the coefficient of correlation also indicate a high degree of negative correlation between the two variables. The two regression equations are written on the basis of the coefficient of correlation and are applicable to predict the value of one variable for a given value of the other variable.

Both, the field observation and the captive study suggest that, if present in large numbers, the Blue Rock Pigeon and the Rose-ringed Parakeet can cause considerable damage to paddy cultivation. Studies conducted on the Blue Rock Pigeon and the Rose-ringed Parakeet in other parts of India show that these birds are harmful to paddy cultivation (Dhindsa and Saini 1994). Hence

their economic status appears to be negative or harmful. The Spotted Munia feeds on the seeds of grasses (Ali 1972) when paddy is not available in the field thus playing a role in the growth of grasses in the field. Moreover, they feed their young ones with larvae of many insects that are harmful to agriculture (Ali and Ripley 1983) thus play a role in the biological control of many insects. When this positive role and the damage they cause to standing crop of paddy are considered together, the impact of munias on the cultivation appears neutral.

Summary and conclusion

Field observations indicated that paddy was the major food item of the three granivorous species of birds at its different stages of ripening. The Spotted Munia took paddy from the milky stage onwards and continued this habit till the end of harvest whereas the Blue Rock Pigeon and the Rose-ringed Parakeet fed on the ripe grains only. All the three species entered the paddy field in flocks, probably to enjoy the benefits of group feeding. But they differed in the resource utilization pattern. The Munias fed after perching on the earhead itself, the Pigeons fed from the fallen earheads or on the discarded grains as they move on the ground and the Parakeets collected and carried away the entire earheads of paddy to their perch site and discarded the earheads without consuming all the grains. Therefore, the extra depredatory loss caused by the Parakeets appeared to be high and that they damaged much

more grains than they actually consumed. The Munias and the Parakeets dehusked the grains before consuming it whereas the Pigeons swallowed the entire grain. The Pigeons consumed more quantity of food and appeared to feed more efficiently than the other two species. The study reveals that, among the three species studied, the capacity to inflict damage on standing crop of paddy is maximum in the case of the Rose-ringed Parakeet and minimum in the case of the Spotted Munia. The flock sizes of all the three species were much smaller than that reported from similar studies in other states. The study indicates that as such, none of the three species caused heavy damage in any of the study areas because of the smallness of the population, but a substantial increase in numbers could cause much harm. The study confirms the suggestion that the Rose-ringed Parakeet can cause serious loss to paddy cultivation.

The study on captive birds indicates that, as observed in the field, the Blue Rock Pigeon and the Rose-ringed Parakeet preferred paddy to any of the other items provided. But the Spotted Munia preferred millets to paddy, indicating their opportunistic feeding and a high degree of flexibility in their food choice behaviour. The observation on the food preference of the birds suggests that the Blue Rock Pigeon and the Rose-ringed Parakeet have natural tendency to feed on paddy. The Spotted Munia feed on paddy, as its preferred grains were not available in the field. Thus, it appears that the hypothesis proposed, the granivorous birds studied in this work are not natural pests of

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paddy and they attained pest status due to habitat degradation, is true only in the case of the Spotted Munia.

The study on captive birds also indicates a high degree of negative correlation between the weight of the body and the actual weight (g) of food consumed/ gram bodyweight. Based on the coefficient of correlation the regression equations of the two variables are written, to predict the value of one variable for a given value of the other variable.

The flock sizes of all the granivorous species of birds observed were small in all the study areas so that no species was a potential threat to the standing crop of paddy. The low population density of these birds may be due to, the large-scale use of lethal techniques to kill these birds for controlling the damage that they cause or the degradation of their natural habitats or excessive use of chemical pesticides or due to the combined effect of these factors. Agricultural areas usually experience heavy and indiscriminate use of pesticides leading to direct and indirect mortality of birds. The Rose-ringed Parakeet and the Munias were trapped in large numbers in these regions for trade purpose and it is speculated that these species face greater threats of extinction in Kerala where paddy fields are shrinking in area. Hence, branding all the granivorous birds as pests and subjecting them to further lethal control measures, may gradually lead to the total elimination of these species from the avian communities in this region. This in turn may result in environmental

problems and upset the balance of nature. For a sustained agricultural production all the existing avian species in balanced numbers are to be conserved in the cultivated landscapes. Hence, in the light of this study, the following recommendations are made for minimizing the loss of paddy due to granivorous birds and to conserve the birds in balanced numbers.

- 1) Proper awareness should be created among farmers and people at large on the importance of the balance of nature and the role played by different groups of animals and plants to maintain it.
- 2) The duration of invasion on paddy by the granivorous birds can be reduced considerably by cultivating paddy that matures uniformly in all the plots in an area.
- 3) To control the damage caused by the granivorous birds in this part of Kerala, nonlethal bird scaring techniques and physical and chemical bird repellants are to be developed and popularized.
- 4) Population sizes of these birds are to be monitored regularly and lethal methods can be considered, only if the population size is too large to inflict serious damage on standing crop.
- 5) The provision of alternative food source to attract the attention of the granivorous birds and thereby reduce the damage inflicted by them appears to be recommendable in the case of the Spotted Munia.
- 6) The damage caused by the Munias, can be minimized by clearing the

roosts and perches like the thickets and small trees close to the paddy fields and by avoiding the cultivation of banana plants close to the paddy cultivation.

- 7) The damage caused by the Blue Rock Pigeon can be controlled effectively by taking measures like, selection of suitable variety of paddy and proper irrigation to maintain the paddy plants erect till harvest.
- 8) The capture of birds for commercial purposes is to be checked effectively by taking stringent legal action.

Since this study is limited to the feeding habits of the birds only in the harvesting season of paddy, a realistic assessment of their economic status is not possible on the basis of this work. Therefore, in future, detailed scientific investigations are to be conducted on the biology of these birds, including, breeding seasons, food and feeding habits in various stages of their life history and their functional role in the ecosystem. Simultaneously, trends in the population density of granivorous birds are to be investigated and measures are to be ensured for the survival of the species that are threatened due to the degradation of their natural habitats.

**ECOLOGICAL STUDIES ON CERTAIN SPECIES OF
GRANIVOROUS BIRDS IN MALABAR**

*Thesis submitted to the University of Calicut
for the Degree of
Doctor of Philosophy
in Zoology*

By

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March 2006

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March 2006

APPENDIX

I. Meteriological Data During the Study Period

(a)Temperature (°C)

Year Month		1993	1994	1995	1996	1997	1998
January	Max.	31.4	32.0	31.9	32.0	32.4	33.9
	Min.	21.4	22.9	22.6	22.8	22.7	23.8
February	Max.	31.9	32.1	32.7	32.6	32.7	34.1
	Min.	22.8	24.0	24.3	23.5	23.0	24.3
March	Max.	32.6	33.0	33.1	33.4	33.8	34.0
	Min.	25.1	25.4	25.2	25.6	25.2	25.5
April	Max.	33.4	32.5	33.5	32.8	33.9	35.4
	Min.	26.2	25.5	25.9	26.1	26.0	27.9
May	Max.	33.4	32.8	32.8	32.9	34.0	34.9
	Min.	26.3	26.1	26.0	26.4	26.4	27.6
June	Max.	30.2	29.1	30.3	30.0	31.0	30.9
	Min.	24.6	23.7	24.8	24.5	24.7	24.7
July	Max.	28.7	27.8	28.5	28.4	29.0	29.5
	Min.	23.5	22.9	23.6	23.7	23.7	24.1
August	Max.	29.1	28.8	28.9	28.8	29.5	30.0
	Min.	23.8	23.6	24.3	23.8	24.0	24.6
September	Max.	30.1	30.7	30.1	29.6	31.2	30.0
	Min.	24.0	23.8	24.5	24.2	24.6	2
October	Max.	30.5	31.3	31.6	30.6	32.7	30.3
	Min.	24.1	23.9	24.5	23.6	24.5	23.9
November	Max.	31.6	32.1	31.2	32.1	32.4	31.9
	Min.	24.1	23.9	24.0	24.3	24.7	24.2
December	Max.	31.5	32.0	32.0	31.9	32.9	32.1
	Min.	23.0	22.3	21.6	22.4	24.9	23.5

(b) Monthly rainfall (in mm.)

Year						
Months	1993	1994	1995	1996	1997	1998
January	0.0	0.0	2.2	0.0	1.8	0.0
February	0.0	0.0	0.0	0.0	0.0	5.8
March	0.8	53.8	0.0	54.7	16.7	14.7
April	9.9	187.4	67.5	42.2	0.0	7.0
May	148.2	59.5	249.9	29.1	68.5	217.4
June	794.7	1083.5	751.3	799.5	996.1	1062.6
July	786.7	1467.1	726.9	872.6	1455.4	779.4
August	286.2	461.2	413.6	324.6	645.5	321.9
September	41.1	177.7	251.9	317.7	218.4	520.2
October	372.3	446.9	185.8	303.0	266.7	429.2
November	166.9	83.4	50.3	28.1	214.4	41.5
December	42.1	12.9	0.0	76.4	50.6	76.9

(c) Monthly mean relative humidity (%)

Year		1993	1994	1995	1996	1997	1998
Month							
January	08.30hrs.	77	77	75	78	80	80
	17.30hrs.	64	66	67	65	65	63
February	08.30hrs.	78	81	80	76	84	75
	17.30hrs.	64	70	70	65	71	63
March	08.30hrs.	77	80	78	80	80	79
	17.30hrs.	71	72	71	71	70	70
April	08.30hrs.	73	79	75	79	75	75
	17.30hrs.	70	74	73	73	69	71
May	08.30hrs.	79	78	79	76	71	75
	17.30hrs.	77	76	73	76	71	75
June	08.30hrs.	89	94	90	88	87	91
	17.30hrs.	84	90	85	84	81	86
July	08.30hrs.	93	96	94	92	93	94
	17.30hrs.	88	91	89	87	90	87
August	08.30hrs.	92	94	93	93	92	93
	17.30hrs.	86	86	87	88	87	85
September	08.30hrs.	88	87	89	91	88	93
	17.30hrs.	81	82	82	84	78	87
October	08.30hrs.	91	90	86	89	86	91
	17.30hrs.	82	79	76	79	77	85
November	08.30hrs.	86	81	85	86	87	85
	17.30hrs.	75	72	76	74	75	75
December	08.30hrs.	81	75	72	81	85	83
	17.30hrs.	70	65	62	69	71	70

II. Statistical Methods Applied

(a) Arithmetic Mean

Arithmetic Mean or the average of a set of values was calculated by applying the formula,

$$\text{Arithmetic Mean, } \bar{X} = \frac{\sum X}{N},$$

where, $\sum X$ is the sum total of the observations, i.e., $X_1 + X_2 + X_3$ X_n ; representing the values of individual items from the first to the last respectively.

(b) Standard Deviation.

The degree of variability between a set of values was estimated by obtaining the value of Standard Deviation using the the formula,

$$\text{Standard Deviation, } \sigma = \sqrt{\frac{\sum d^2}{N} - \left(\frac{\sum d}{N}\right)^2},$$

Where, d = deviation of individual value from the assumed mean A ,

i.e, $d = (X - A)$,

$\frac{\sum d^2}{N}$ is the mean of the squared deviations of individual values from the assumed mean, ie,

$$\frac{\sum d^2}{N} = \frac{(X_1 - A)^2 + (X_2 - A)^2 + (X_3 - A)^2 + \dots \dots \dots (X_n - A)^2}{N}$$

and $\sum d$ is the sum total of the individual values from the assumed mean A ,

$$\sum d = (X_1 - A) + (X_2 - A) + (X_3 - A) + \dots + (X_n - A)$$

(c) Coefficient of Correlation

The degree of relationship between the two variables in the study, the mean body-weight (X) and the actual mean weight of food consumed/gram body weight (Y) of the birds was determined numerically by obtaining the value of Karl Pearson's co-efficient of correlation ' r ', using the formula,

$$\text{Co-efficient of correlation, } r = \frac{P_{xy}}{S_x S_y},$$

Where, P_{xy} or Cov.XY is the average of the joint variation of the two variables X and Y , S_x and S_y are standard deviations of X and Y respectively. The value of Cov.XY or P_{xy} was obtained by applying the formula,

$$P_{xy} = \frac{\sum (X - A)(Y - B)}{N} - \frac{\sum (X - A)}{N} \frac{\sum (Y - B)}{N},$$

where, X and Y represent values of the first and second variables respectively and A and B represent values of the corresponding assumed means. Substituting d_1 and d_2 for $(X - A)$ and $(Y - B)$ respectively, then,

$$P_{xy} = \frac{\sum d_1 d_2}{N} - \left(\frac{\sum d_1}{N} \right) \left(\frac{\sum d_2}{N} \right)$$

(d) Regression Equations

The regression analysis is made on the basis of P_{xy} . The regression equation, X on Y is written on the assumption that, as the X value changes there is a corresponding change in the Y value. Similarly, the equation Y on X is written on the assumption that as Y value changes, there is a corresponding in the X value.

The regression equation X on Y is,

$$X - \bar{X} = \frac{P_{xy}}{S_y^2}(Y - \bar{Y})$$

and that of Y on X is,

$$Y - \bar{Y} = \frac{P_{xy}}{S_x^2}(X - \bar{X})$$

where,

$$P_{xy} = \frac{\sum(X-A)(Y-B)}{N} - \frac{\sum(X-A)}{N} \frac{\sum(Y-B)}{N},$$

\bar{X} and \bar{Y} are the arithmetic means and, S_x^2 and S_y^2 are the variances or squares of standard deviations of X and Y respectively. i.e.,

$$S_x^2 = \frac{\sum d_1^2}{N} - \left(\frac{\sum d_1}{N}\right)^2 \quad \text{and} \quad S_y^2 = \frac{\sum d_2^2}{N} - \left(\frac{\sum d_2}{N}\right)^2$$

(e) Testing the significance of difference between sample arithmetic means.

The significance of difference between sample arithmetic means was tested statistically using the **t**- test. The value of the test statistic '**t**' was calculated as,

$$t = \frac{X_1 - X_2}{S.E.},$$

The Standard Error or S.E. was calculated as ,

$$S.E. = \sqrt{\frac{n_1 S_1^2 + n_2 S_2^2 \left(\frac{1}{n_1} + \frac{1}{n_2} \right)}{(n_1 + n_2 - 2)}},$$

where, n_1 and n_2 are the sizes and S_1^2 and S_2^2 are the variances of the first and second samples respectively.

The calculated value of **t** was compared with the table value at 0 .05 level of significance and $(n_1 + n_2 - 2)$ degrees of freedom.

III. Avifauna of the study sites

(a) List of birds sighted

Sl.No.	Common name	Scientific name
1.	Little Egret	<i>Egretta garzetta</i>
2.	Cattle Egret	<i>Bubulcus ibis</i>
3.	Pond Heron	<i>Ardeola grayii</i>
4.	Purple Moorhen	<i>Porphyrio porphyrio</i>
5.	Shikra	<i>Accipiter badius</i>
6.	Bluerock Pigeon	<i>Columba livia</i>
7.	Spotted Dove	<i>Streptopelia chinensis</i>
8.	Roseringed Parakeet	<i>Psittacula krameri</i>
9.	Palm Swift	<i>Cypsiurus parvus</i>
10.	Blossomheaded Parakeet	<i>Psittacula cyanocephala</i>
11.	Small green Bee-eater	<i>Merops orientalis</i>
12.	Whitebreasted Kingfisher	<i>Halcyon symrensis</i>
13.	Red-rumped Swallow	<i>Hirundo daurica</i>
14.	Black Drongo	<i>Dicrurus adsimilis</i>
15.	Indian Myna	<i>Acridotheres tristis</i>
16.	House Crow	<i>Corvus splendens</i>
17.	Streaked fan-tailed Warbler	<i>Cisticola juncidis</i>
18.	Magpie-Robin	<i>Copsychus saularis</i>
19.	Whitebacked Munia	<i>Lonchura striata</i>
20.	Spotted Munia	<i>Lonchura punctulata</i>

(b) Occurrence ratio of the birds observed

Occurrence Ratio	Birds
7/7	Little Egret, Pond Heron, Bluerock Pigeon, Whitebreasted Kingfisher, Black Drongo, Indian Myna and House Crow
6/7	Magpie-Robin
5/7	Cattle Egret, Roseringed Parakeet and Small green Bee-eater
4/7	Shikra and Whitebacked Munia
3/7	Purple Moorhen, Spotted Dove, Palm Swift, Blossom headed Parakeet, Red-rumped Swallow and Streaked fan-tailed Warbler
2/7	Spotted Munia



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