RESOURCE UTILIZATION BY *BIRDS* ATTENDING *FIGS* IN SOUTH INDIA

Thesis Submitted in partial fulfilment of the requirements for the award of the degree of Doctor of Philosophy in Zoology

by

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Declaration

I hereby declare that the thesis entitled "Resource Utilization by Birds Attending Figs in South India" 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.

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Certificate

This is to certify that this thesis is a record of the bonafide research work carried out by Shri. Vijayakumar. T. N., M. Sc. M. Phil. under our 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.

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INTRODUCTION AND REVIEW OF LITERATURE

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Plate 1

CHAPTER 1

INTRODUCTION AND REVIEW OF LITERATURE

Introduction

Many plants have their seeds dispersed by frugivorous birds (Home and Smallwood, 1982). Fleshy fruits, which are packages containing seeds enveloped in nutritive pulp are eaten by birds, which digests the pulp and disperse the seeds (Herrera 1984). Plants of the genus *Ficus* are common in tropical forests (Breitwisch, 1983) and figs constitute a larger proportion of the diet for several vertebrate species than the fruits of any other perennial plant genus (Janzen, 1980).

Accounts of figs utilization by avian frugivores in the tropics included those of McClure (1966); Terborgh and Diamond (1970); Snow and Snow (1971); Wells (1975, 1982); Kantak (1979); Snow (1980); Brockelman (1982); Breitwisch (1983); Jordano (1983); Pratt (1983); Scott and Martin (1984); Wheelwright et al. (1984); Coates-Estrada and Estrada (1986); Terborgh (1986); Lambert (1987); and Gautier-Hoin et al. (1989). Eventhough figs are poor in nutritional quality (Morton 1973; White (1974), Frost (1980); Herrera (1981); Leighton (1982), they play a 'Key role' in the diet of frugivorous animals through periods of general fruit scarcity at least in two tropical forest areas (Leighton and Leighton, 1983; Tereborgh 1986). The aseasonal and round-the-year fruiting phenology of Ficus (e.g; Mc Clure 1966; Medway 1972; Raemackers 1980; Corlett 1984) suits it to accomplish this role. Lambert (1987, 1989) has described other chracteristics of Ficus which made them important in avian frugivore survival in an area.

Despite the abundance of this genus and its importance in the diet of frugivores of old world forest, systematic studies have not been conducted on the avian assemblages of Ficus taxa at any single site (e.g. Lambert 1989). Most of the informations gathered were restricted to a single tree or species (Brockelman 1982; Breitwisch 1983; Coates-Estrada and Estrada 1986).

The mutualistic interaction between Ficus species and frugivores has not been studied in the Indian sub-continent, though their importance in the diet of various avian frugivores had been mentioned by Salim Ali (1983). The present investigation was aimed at studying the utilisation of figs by the diverse assemblage of fruit-eating birds and their mutual interaction in two tropical habitats of Calicut and Wynadu in Southern India. The major objectives are to study:

1. the mutualistic interaction existing between bird-fruits and fruit-birds in a tropical habitat;

2. the importance of figs in the diet of bird community in the tropical habitat;
3. the pattern of partitioning of a common food resource by various bird species;
4. the intraspecific and interspecific competition within the frugivore community;
5. the role of avian frugivores in fig seed dispersal etc.

Review of Literature

A study of plant and animal interactions is vital to answer many ecological problems. Thirty five to Ninety five percent of tree and shrub species in Old and New World tropical forests bear fleshy fruits varying in size, colour, presentation and structure (Howe and Smallwood 1982). These fruits attract birds and mammals, ranging in size from 10 to 10^7 gms, which may disseminate, digest or simply destroy seeds (Howe 1976). A knowledge of the ways in which birds exploit resources within a forest will help not only to understand how they use their environment and also to identify the features of that environment which are necessary for their survival. This information in turn is required for evaluating the mechanisms of habitat selection, foraging theory, competitive relations and community structure (Resher et al. 1985). Avian frugivory and seed dispersal have been studied much earlier (Wetmore 1914; Wood 1924; Ridley 1930; Schuster 1930). Models and predictions have been elaborated on the basis of resulting field evidence which relate features of seed dispersal performed by the birds to aspects of plant fruiting strategy like crop size, fruiting phenology and fruit quality (Snow 1965, 1971; McKey 1975; Howe and Estabrook 1977; Howe 1979). Studies of birdfruit - fruit-bird interaction systems included those of Land (1963) Willis (1967), Diamond and Terborgh (1967); Lack and Hilty (1968), Leck (1969), Terborgh and Diamond (1970), Leck (1971), Cruz (1974); Howe (1977); Kantak (1979); Howe and Desteven (1979), Howe and Vandekerckhove (1979), Herrera (1981, 1990), Stiles (1980), Herrera and Jordano (1981), Jordano (1981), Jordano and Herrera (1981), Sorensen (1983), Wheelwright (1985) and Lambert (1989); Their mutualistic and coevolutionary significance have been recognized by Snow (1971), McKey (1975), Howe and Estabrook (1977), Howe and Smallwood (1982) and Herrera (1982b, 1983). Howe and Smallwood (1982) assumed that every participant may exert selective pressures on the other part, and some phenotypic traits of both plants and avian seed dispersers may evolve in response to these pressures. Crome's (1975) study of fruit pigeons in tropical Queensland suggest coevolution with or at least dependence on fruiting plants at the family level as in Quetzals (Wheelwright 1983). A specialized and obligate relationship was proposed between a tropical plant Calvaria majour and its disperser, the Dodo (Raphus cucullatus (Temple, 1977). Following Dodo's extinction 300 years ago, Calvaria seeds had failed to germinate because they apparently depended upon scarification during digestion by dodos. Herrera (1986b) observed considerable constancy in the structure of the plant-bird interaction at the community level. According to him local fruiting plant assemblages have been shaped through interaction with dominant frugivores. He postulated that the dominant frugivores by occurring in most habitat types, promote a sort of regional convergence in local fruiting assemblages. This results in similar interaction matrices. If frugivores are generally more predictable in space than plants, then one would expect the set of regionally dominant birds to evolutionarily drive system. This would give rise to plant convergence in fruit features (e.g. Size, colour) as well as various sorts of diffuse coevolutionary processes (Herrera 1982). Sherbourne (1971) and Thompson and Willson (1979) were of the view that fruits may compete more heavily for birds than birds for fruits.

Many studies on the evolutionary ecology of plant-disperser interactions have emphasized plant adaptations for efficient seed dispersal (e.g.Howe and Estabrook 1977; Howe and Vandererckhove 1979, 1980; Thompson and Willson 1979; Fleming 1981; Herrera 1981c, 1982a; Denslow and Moermond 1982; Stiles 1982; Willson and Thompson 1982). Some researchers expect a more general relationship such as mutual dependence of birds and a frugivore guild rather than the evolution of the one-to-one mutualisms between individual species of plants and fruit-eating birds (Howe and Vanderkerckhove 1981; Snow 1981; Thompson 1982; Wheelwright and Orians 1982). For example, birds in the genera Ptilinopus, Ducula (Crome 1975), Procnias (Snow 1971) and Pharomachrus (Wheelwright 1983) feed heavily on fruits of Lauraceae as a group, and Treron Pigeons (Lambert 1989) on fruits of Moraceae. Cassowaries in the North Queensland's rainforest are primarily dependent on the fruits for their survival (Crome 1976; Stocker and Irvine, 1983). Ridley (1930) has reported cassowaries as dispersing some species on the Ceram and the Aru Islands Herrera (1984a) observed that the actual reciprocity occurs only in a few bird-plant species pairs at every site, while in the majority of cases plants are much less important to dispersers than dispersers are to plants. Most fruit-eating birds utilised only a portion of the diversity of fleshy fruits produced in any habitat (Snow 1970, Snow 1981).

Studies on seed dispersal by avaian frugivores in the tropics included those of Snow (1971), Vander Pijl (1972), Howe (1977, 1979), Stiles (1980), Greenberg (1981), Herrera (1982b), Wheelwright (1983), and Lambert (1989). Studies were conducted on frugivores associated with neotropical trees producing high quality fruits (Sensu Mckey 1975; Howe and Estabrook 1979, 1981) and low quality fruits (Howe 1980). The families of Lauraceae and Moraceae supported large numbers of avian frugivores in the Costa Rican tropical forest (Wheelwright et al, 1984).

In the tropical habitats figs (Moraceae) have long been recognized as an important food for vertebrate frugivores (Hladik et al., 1971; Leck 1972; Flemminget al. 1977; Bonaccorso 1979; Jordano 1983; Lambert 1989). The fig consumer assemblage is among the most diverse reported for tropical trees with regard to species number and taxonomic affinites (Jordano 1983). The 900-odd species of *Ficus* (Corner 1958, 1962) constitute the most distinctive of the widespread genera of tropical plants. Figs are found in almost all tropical habitat types and geographical locations. Mature fig trees are most common in moderately disturbed sites such as riparian edges, tree crowns (as epiphytes), tree falls, secondary agricultural regenration and old land sides. The fig syconium is a globular inflorescence and is regarded ecologically as the fruit (Janzen 1979; Milton et al., 1982).

Figs constitute a major fruit food for more species of animals than any other genus of wild tropical perennial fruit (Janzen 1979). Ridley (1930) recorded 44 tropical species of brids, bats and non-volant mammals feeding figs. McClure (1966) lists 32 speces of Vertebrates feeding on the figs of a single tree of *Ficus sumatrana* in west Malaysia. Brosset and Erard (1986) observed that figs were eaten by 6 of 15 species of Pycnonotidae by 2 of 4 sturnidae and 3 of 8 species of Columbidae in north eastern Gabon. Leighton and Leighton (1983) and Terborgh (1983) considered figs as critical species for the maintenance of biological diversity in tropical forests. In both the Old World (Leighton and Leighton 1983) and the New World (Terborgh 1983) figs have been considered Keystone resources, Key components of food web whose disappearance would cause cascading extinction.

On Barro Colorado Island, Panama, figs are one of the very important fruit resources available during the late raining season (Foster 1982). It has been suggested that if fig species were removed from tropical communities, some of these frugivores would face local extinction. Other plants dependent on those animals would suffer population reductions, possibly dragging other bird species with them in their demise (Leighton and Leighton 1983; Terborgh 1983, 1986). This effect may be most striking in highly fig dependent vertebrates such as some birds-of-paradise in New Guinea (Beehler 1983), frugivovrous bats in Panama (Morrison 1978) and squirrel, monkeys and capuchins in Amazonia (Terborgh 1983) and fruit pigeons in Malaysia (Lambert 1989). However according to Gautier-Hion et al., (1989) in areas with low fig densities and relatively smaller fig crops, animal's dependence on them may be less.

Theoretical studies have categorised the tropical avain frugivores into two types, namely "specialized" frugivores which ate mostly fruit and "opportunists" which forage on insects and also fruits or nectar or foliage (Snow 1971; Mckey 1975; Howe and Estabrook 1977). Mackey (1975) predicted that mutualism in seed dispersal systems is likely to involve bird families with obligate frugivory. Herrera (1984) considered the primary dispersers as "specialised" dispersers. Birds are also determined as specialized based on the frequency of frugivory (Wheelwright and Orians 1982) or on the quality of seed disersal they deliver (Howe and Estabrook 1977) or on the characteristics of the fruits they select (Snow 1981). Avian frugivores are also ditinguished as "legitimate" seed dispersers and fruit "predators" (eg. Snow 1971; Herrera 1984). The former ingest whole fruits, either regurgitate or defaecate the seeds intact while the latter feed on either pulp or seeds alone and when eating pulp and seeds together damage the seeds either in the gut or prior to swallowing. Howe (1977) and Herrera (1984) observed that a few species may be legitimate dispersers of some plants and fruit predators of others. Tityra semifasciata (Contingidae), a reliable "specialized" frugivore behave as a legitmate disperser of Casearia corymbosa (Howe 1977) while on Virola surinamensis it becomes a fruit thief and drop the seeds below the parent tree and ingest only the aril (Howe and Vandekerckhove 1980).

The avain preference to different fruits have been attributed to different factors like fruit abundance (eg. Snow 1962; Crome 1975; Thompson and Willson 1979; Sorensen 1981), the nutritional and energy reward of fruits (Snow 1962; Howe 1971; Snow 1971; Willson and Thompson 1982; Herrera 1984b), accessibility and size of fruits

(Diamond 1973; Snow 1977; Kantak 1979; Sorensen 1983; Wheelwright 1983); the weight of seed "ballast" in fruits (Howe and Vandekerckhove 1980; Herrera 1981), the taste (Diamond 1960; Warren and Vine 1963; Harriman 1968), the fruit colours (Ridley 1930; Turcek 1963; Vanderpijl 1972; Janzen 1983; Wheelwright and Janzen 1985). Small fruited plant species have been hypothesized to attract more species of birds than large fruited ones (Terborgh and Diamond 1970). Kantak (1979) described that the intermediate sized fruits attracted the greatest number of bird species among the five plants she studied in Mexico. Diamond, (1973) and Herrera and Jordano (1981) also described the determinant role of fruit size to the constitution of avian assemblage on plants. Most fruit-eating birds are "gape - limited" (Zaret 1980; Wheelwright 1985), though there were no strict correlation existing between gape-width and fruit size (Wheelwright 1985). Howe (1977) suggested that the dispersal agents tend to avoid trees with heavy fruits. Theory predicts that animals favour the most "profitable" food, the more common it is (Mac Arthur 1972). According to Herrera (1981) foragers ate more fruits from trees with a high benefit in edible pulp for the cost of carrying bulky seed ballast than they do from others. Digestibility (MacFarland and George 1973); Fattyacids (West and Mong 1968); aminoacids (Pendergast and Boag 1971); and sugars (Kare and Medway 1959) have been found to influence avian food selection. The plant growth form, commonness and fecundity influence the number of dispersal agents of a plant (Wheelwright et al. 1984). The avian assemblage and fruit removal rate in forest trees were influenced by the microhabitat (Thompson and Willson 1978; Moore and Willson 1982; Willson et al. 1982). It was assumed the bird-disseminated plants have evolved fruits with above attributes such as bright colouration, accessibility, convenient size, persistence, nutritional reward etc. to be attractive to birds (Ridley 1930; Turcek 1963; Snow 1971; Vander Pijl 1972; Howe and Smallwood 1982; Denslow and Moermond 1982; Willson and Thompson 1982; Janzen 1983; Pratt and Stiles 1983).

According to Janzen (1979, 1979b), the figs. are being eaten by several kinds of animals because of some of the above characteristics. They are juicy with edible pulp The seeds are non-toxic. Figs occur in large numbers and in most tropical habitats ripe figs are available round the year. They occur in a range of sizes. Morrison (1978) suggested that figs probably represent a readily utilisable source of calories and water but fail to provide a balance diet to frugivores feeding on them. Certain vertebrates such as fruit bats (Bonaccorso, 1979, Janzen 1979) and fruit pigeons (Lambert 1989) are fig specialists.. The intracrown synchrony and intercrown asynchrony of figs and by being relatively a rare tree when in fruit, figs have a minimum chance of competitively excluding each other over the service of dispersal agents (Janzen 1979).

The "prey" of frugivore bird species differ from the prey of carnivores because many plants benefit by having their seeds disseminated (Ridley 1930; Vander Pijl 1969; Howe and Smallwood 1982) most bird-dispersed fruits are not difficut to detect or handle (Snow 1971; Wheelwright 1983). Fruits rarely require crushing (in contrast to seeds, willson 1971) or dexterous manipulation (in contrast to animals Prey, Ashmole 1968).

Regarding frugivory, Snow (1976) writes: it is apparently, the relief from the need to spend most of the day in search of food that has given the fruit-eaters the opportunity to develop other activities to a degree not seen in the insect eaters.

STUDY AREA AND METHODS

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CHAPTER 2

STUDY AREA AND METHODS

Study Area

Site - I : Calicut University Campus, Tenhipalam.

The Calicut University Campus (hereinafter called 'Tenhipalam Site' or 'Site I') lies in the Tenhipalam village of Malappuram District of Kerala between latitude 11° 35'-45" N and longitude 75°, 45'-50" E. It lies about 60 M above sea level. The National highway NH - 17 divided the campus into eastern and western sectors. The botanical garden of the University cover an area of about 40 ha. A large outdoor stadium lies between these gardens. The main administrative blocks and teaching departments are situated in the South-Western and Northern portions of the campus (Fig. 1).

The terrain is undulating with grassy meadows, rocky promontories and ravines. The soil is laterite supporting a tropical vegetation characterising a secondary scrub jungle (Plate 2). Patches of woodlots are present at various pockets. *Acacia auriculiformis* and *Casuarina equisetifolia* are grown as part of social forestry in certain portions of the campus.

Fig1 Map of the study area, Calicut University campus

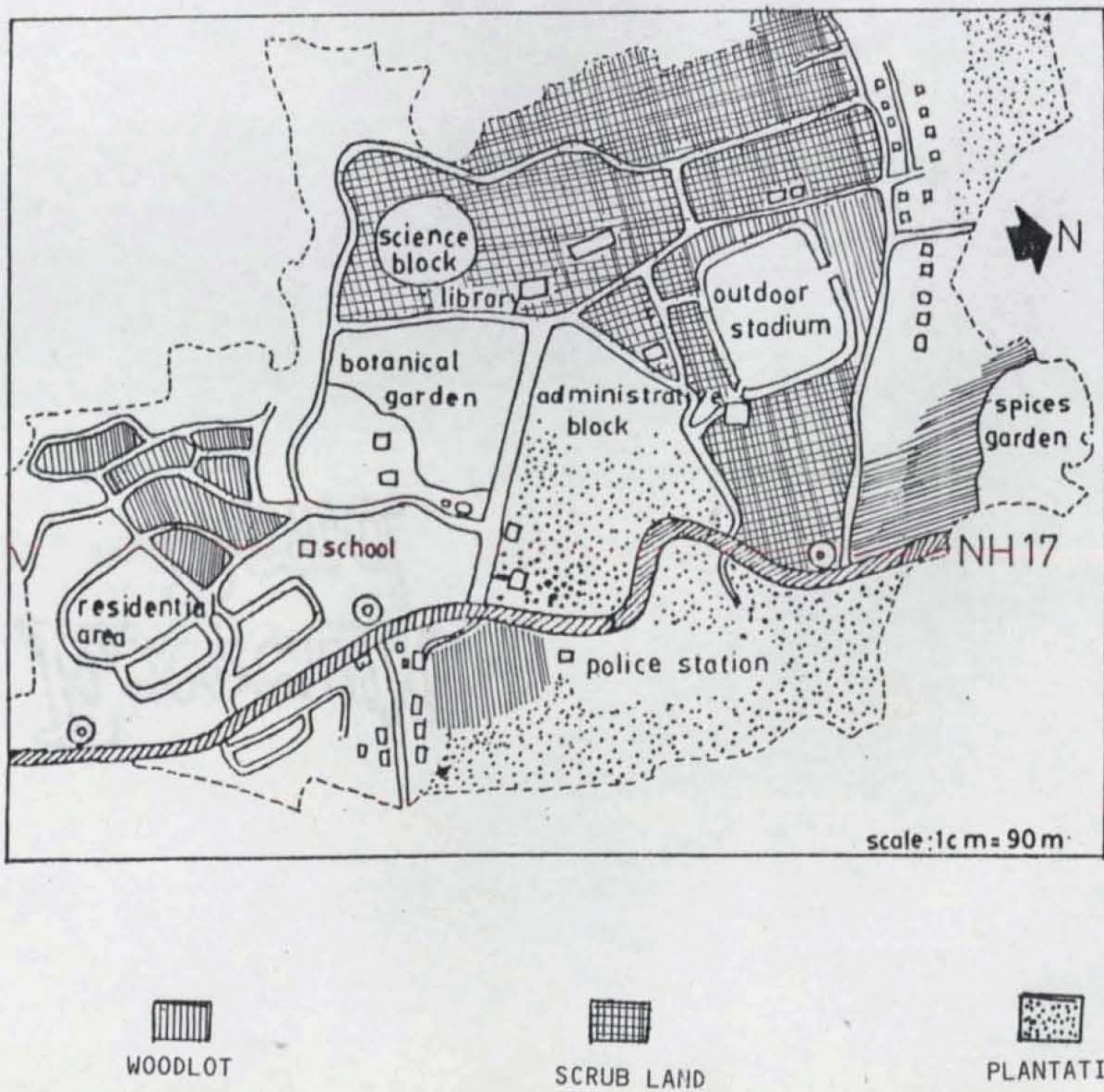


TABLE 2. **Monthly rainfall at Calicut (Courtesy CWRDM, Calicut)**

Sl. No.	Month	1989 (in mm)	1990	1991	1992	1993
1.	January	--	11.00	--	--	--
2.	February	--	--	--	--	--
3.	March	0.80	--	3.40	--	--
4.	April	59.40	--	61.60	19.00	16.40
5.	May	242.30	592.90	34.20	161.40	210.30
6.	June	920.40	537.90	1002.00	918.90	737.60
7.	July	475.10	705.10	1001.00	895.50	836.40
8.	August	365.20	331.10	593.90	592.60	352.40
9.	September	213.80	77.30	14.70	244.60	52.50
10.	October	216.20	356.10	336.76	349.00	307.80
11.	November	55.20	112.80	91.80	193.50	104.00
12.	December	01.40	--	--	--	65.20
		2549.80	2724.20	3139.40	3374.50	2682.60

Fig. 2. Seasonal availability of ripe figs of six *Ficus* species in the Tenhipalam site (a) during 1990-91 (b) during 1991-92

Fre - *Ficus racemosa*; Fb - *Ficus benghalensis*

Fe - *F. exasperata*; Fr - *F. religiosa*;

Fa - *F. amplissima*; Ft - *F. tsjahela*

(Astrix on band shows sparse availability).

Plate 2

TABLE 1. **Mean monthly minimum and maximum temperature during the study period at Tenhipalam site**

Sl. No.	Month	1989		1990		1991		1992		1993	
		Min.	Max	Min	Max	Min	Max	Min	Max	Min	Max
1.	Jan	21.3	32.6	21.1	30.7	21.0	30.92	19.1	31.4	19.9	32.8
2.	Feb	21.6	33.30	22.9	32.2	22.1	32.43	22.4	32.15	21.17	33.4
3.	March	23.9	34.4	24.0	34.50	24.68	34.85	23.7	34.2	24.2	34.3
4.	April	25.60	34.1	26.3	35.30	25.30	33.33	25.3	34.9	24.1	35.1
5.	May	25.0	32.4	25.8	32.4	26.40	33.10	25.9	33.8	25.3	34.4
6.	June	23.2	28.7	24.5	30.2	24.5	29.35	24.1	30.0	24.3	31.0
7.	July	23.5	28.7	23.1	28.9	23.5	29.6	23.4	29.3	23.5	29.5
8.	Aug	24.5	28.4	23.7	29.4	23.4	28.9	23.50	28.8	23.5	29.7
9.	Sept	24.7	29.1	24.00	30.6	24.5	30.5	24.2	30.20	23.7	31.0
10.	Oct	24.8	30.0	23.8	31.9	24.4	30.1	25.07	30.01	23.8	31.2
11.	Nov	24.1	30.9	23.20	30.15	24.2	31.0	24.3	30.3	23.2	32.2
12.	Dec	23.3	31.07	21.80	31.58	22.2	30.4	20.5	32.9	22.0	32.4

Climate

Calicut and surrounding areas have a hot and humid climate and was described by Zacharias and Gaston (1983). The temperature fluctuations were relatively mild and varies between 20^{o} C and 35^{o} C during the present study (Table 1). The highest temperature was recorded in summer which begins towards the latter half of February and extends through May. The rainy season often starts by the last week of May with the arrival of South-West monsoon. It extends from June through September. The precipitation occurred intermittently during October and November months due to the north-east monsoon. However, the heaviest shower occurred in June-July months (Table 2). The winter was very mild spreading through December and January.

Flora

The campus vegetation has been described by Manilal and Sivarajan (1976). They have recorded 447 species of plants. The area has then undergone a lot of degradations in the recent past. The tree species are rather sparsely distributed. Many annuals are seen durig monsoon season all of which disappear soon after the rain. The important tree species of the area included *Ceiba petandra*, Gaerth., *Terminalia paniculata* Roth., *Terminalia bellerica* Roxb., *Bridelia retusa* sprung; *Macaranga peltata* Muell. Arg., *Santalum album*

Linn., *Phyllanthus emblica* Linn., *Alstonia scholaris* R. Br., *Olea dioica* Roxb., *Artocarpus hirsuta* Lamk., etc. The fig community included species such as *Ficus benghalensis*; *F. amplissima* Smith, *F. racemosa*, *F. religiosa*, *F. exasperata* Vahl., *F. tsjahela* Burm. f., etc. Other common woody trees of the site are *Anacardium occidentale* Linn., *Mangifera indica* Linn., *Artocarpus* integrifolia Linn., *Sterculia guttata* Roxb., *Mimusops elengi*., *Syzigium caryophyllaeum*., *Syzigium cumini*., *Cinnamomum veerum* etc. *Acacia auriculiformis* A. Cunn., and *Casuarina equisetifolia* forst., are grown under social forestry programme.

The shrub community consists of plants like *Canthium parviflorum*, *Zizyphus oenoplia* ., *Lantana camara* Linn., *Hystonia mystax*., *Bridela scandens*., *Breynia vitis-idea* etc. The herbaceous plants like *Leea indica*., *Ixora coccinea*., *Rawolfia tetraphylla*., *Eupatorium odoratum*., and vines like *Anamirtta cocculus*., and *Cissus glauca* are well distributed in this study area. Fleshy fruit producing plants form a significant fraction of the fruiting plants here.

Site – II : Vattappara, Vythiri

The Vattappara study area (hereinafter called 'Vythiri Site' or 'Site II') lies in the Vythiri village of Wynadu district of Kerala within the latitude 11° 6'-36" N and longitude 76°30'-12" E. Its

Plate 3. View of Vythiri study area

Plate 3

TABLE 3. **Mean, minimum and maximum temperature at Vythiri** (courtesy Rajapushpam Plantations, Vythiri)

Sl. No.	Month	1989		1990		1991		1992	
		Minimum	Maximum	Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
1.	January	12.30	22.50	12.60	22.4	12.32	20.36	12.78	21.19
2.	February	15.80	25.30	16.10	26.7	15.40	25.2	14.77	24.33
3.	March	19.70	32.8	20.4	32.60	19.90	34.33	18.52	33.87
4.	April	21.4	34.23	22.9	34.8	22.06	33.70	21.16	34.15
5.	May	20.14	30.15	19.4	32.3	23.28	33.26	22.71	34.62
6.	June	19.80	29.4	19.6	29.30	19.90	32.18	19.62	29.40
7.	July	19.90	29.20	19.67	29.44	19.86	29.71	19.88	28.16
8.	August	19.06	28.20	19.9	29.90	19.31	29.50	19.33	28.07
9.	September	18.03	27.40	18.78	28.16	19.12	26.84	18.24	25.61
10.	October	17.35	25.60	17.17	24.30	15.62	26.40	16.33	24.88
11.	November	14.11	24.76	13.89	24.10	13.36	21.11	12.98	22.16
12.	December	13.36	23.87	13.04	23.77	12.74	20.83	12.91	21.78

TABLE 4. **Mean monthly rainfall at Vythiri** (Courtesy - B&R Brothers Planters, Vythiri)

Sl. No.	Month	1988	1990	1991	1992
1.	January	0	37.30	0	0
2.	February	0	0	1.25	3.75
3.	March	2.40	0	2.00	0
4.	April	72.40	21.25	111.50	120.25
5.	May	368.50	952.60	59.25	187.75
6.	June	1505.25	1030.15	1664.50	1703.75
7.	July	1027.56	1408.70	1585.45	1507.20
8.	August	629.14	608.60	837.20	1187.35
9.	September	308.30	164.35	72.60	603.70
10.	October	237.40	306.40	278.68	266.35
11.	November	83.95	132.05	120.85	387.05
12.	December	4.60	2.10	3.00	3.00
		4239.50	4663.50	4738.28	5970.15

altitude ranges between 800-1200 m. It forms a part of the western stretch of the Western ghat and is a moist deciduous forest habitat (Plate 3). The terrain is mountainous with rocky promontories and ravines. The soil is black and fertile, typical of tropical forest habitat.

The site spreads through an area of 310 hectares and is a vested forest mostly degraded for cultivation of cardamomum, Pepper and Coffee. About 155 ha of land is under cardamomum and about 50 ha is under coffee crops. The remaining land area which is also degraded for cardamomum has been left unutilised for the last 7 to 10 years.

Climate

Vythiri has a highly humid climate. The temperature fluctuations here are greater than in the campus site due to its higher attitude. It ranges from 12^{o} C to 33^{o} C (Table 3). The rainfall is usually abundant. The precipitation occurred mostly due to the south-west monsoon. It begins by the end of May and spreads through September. Some pre-monsoon showers are obtained during April and early May. Monsoon rainfall occurred in June-July months (Table 4). The North-East monsoon, which occurred in October-Novemebr months has brought relatively poor and intermittent showers for the last few decades. There was heavy mist, covering the land surface which occurred intermittently during the day in monsoon season. The winter season which spread through December and January was colder than that in the campus site. The minimum temperature recorded was 12^{o} C. in January (Table 3).

Flora

The vegetation is typical of moist deciduous forest habitat. However, majority of the tree species in the degraded area are secondarily grown. The secondary forest is about 50 to 60 years old (Balasubramaniam, Personal communication). However, some trees of species such as *Dysoxylum malabaricum* bedd., *Dysoxylum beddomei* Hem.; *Vateria indica* Linn., *Steriospermum suaveolens* (Rox.) D.C. *Dalbergia latifolia* Rox., and various *Ficus* plants are remnants of the primary forest. The vegetation consisted primarily of woody plants; the undergrowth being cleared for cultivation. Trees with thick foliage and large crown volume were preferred as shades for cardamomum plants. The plants of Moraceae formed a prominent fraction of the tree community.

Some of the important woody plants of the area are *Hydnocarpus alpina* wight., *H. petandra* (Buch-Ham) Oken., *Calyophyllum wightianum* T. Ant., *Garcinia cambogia* (Gaertn) Desr., *Dipterocarpus indicus* bedd., *Vateria indica* Linn., *Thespesia populnea* Cor., *Cullenia zeylanica* wight K. Chem., *Sterculia allata* Roxb., *Grewia tilliaefolia*

Vahl., *Elaeocarpus serratus* Linn., *Elaeocarpus tuberculatus* Roxb., *Arotocarpus hirsuta*., *Erythrina lithosperma*., *Pterocarpus marsupium* Roxb., *Pterocarpus santalinus* Linn., *Eugenia gardneri* Thw. *Olea dioica* Roxb., *Machilus macrantha* Nees., *Actinodaphne madraspatna* bedd., *Macaranga peltata* Muell Arg., and *Mallotus alba* Muell Arg. etc. The important wild fig species included *Ficus microcarpa*, *Ficus virens*., *F. beddomei* King, *Ficus nervosa* Heyne Ex. Roth., *F. amplissima* Smith, *F. exasperata* Vahl. and *F. tsjahela* Burm. f. The shrub and herbacious plant community which are rather sparsely distributed, particularly in the crop cultivated portions included *Maesa perrottetiana* A. DC., *Lantana camara* var. *aculeata*, *Desmodium gangeticum* DC, *Toddalis asiatica* L., *Bridelia scandens*, *Calycopterys floribunda* Lam., *Antidesma* sp., *Oclandra travencorica* Benth. etc.

Material and Methods

Data on fruiting plants and fruit-eating birds were gathered during census conducted every fortnight. The line transect and point transect methods were used for monitoring. Each census was started at 6.30 h in the morning and lasted 6 to 7 hours. A 6 x 30 prisom binoculars was used for observation. While moving along the transect all fruiting plants and birds seen on either side of the transect line were recorded. The species of plants in fruit, stages of flowering and fruiting are noted. The nature of feeding and food of a species of bird were recorded to identify the frugivorous species. Sometimes deviations from the usual path were taken to have closer observation of birds. The point transect or 'spot map' method was more useful in assessing the abundance of each bird species (Blondel, Ferry, Frochot 1970). In the present study it was found to be an effective strategy in the assessment of avian frugivores which usually congregated on certain preferred fruit sources. A separate bird activity census was also conducted at each Ficus species and various bird species foraging on the fig in each hour of observation were recorded.

Site 1: Tenhipalam Site.

Three line transects, each having a length of about 100 M, were selected in this area. The transects were prepared so as to encompass the major fruiting trees that attracted most of the avian frugivores. For point transect study 11 points were selected and 15 minutes were spent at each place recording the foraging bird species. A total of 14 fig species were identified in the campus site. Avian assemblages on 10 fig species which produced enough crops were recorded (Table 10). The other four species of figs such as F. benjamina, F. virens, F. mysoorensis and F. careca were either very rare or represented by immature trees and were not sufficiently fruited to attract avian frugivores. However, more extensive studies were conducted only on Six *Ficus* species such as *Ficus benghalensis*, *F. exasperata*, *F. racemosa*, *F. religiosa*, *F. amplissima* and *F. tsjahela* which were more common and produced abundant crops.

Site – II – Vattappara, Vythiri

Because of the particular topography of the area, a more or less circular route was taken in line transect. It ran a distance of about 8 km and passed through almost the centre of the study area. The point transect had 29 points and 10 minutes was spent at each place. Ten species of figs were identified in this site and avian fig-eating assemblages on seven of them were recorded (Table 11). Other three species of figs *F. racemosa*, *F. mysoorensis*, and *Ficus* sp. were either very rare or were represented by immature trees. More extensive observations were carried out on six species of very common and abundantly fruited figs such as *F. beddomei*, *F. amplissima*, *F. exasperata*, *F. nervosa*, *F. tsjahela* and *F. microcarpa*.

Fruiting Phenology of *Ficus* species

Ficus trees of all species were marked at site I during late 1989 and at site II during late 1990. The various fig species were identified by comparing the collected specimens with herbarium collections. The chronology of flowering and fruiting of different figs were recorded (Fig. 2 & 3). On each occasion the developmental stages of syconia as distinguished by their size, colour and softness of pericarp were noted. The crop size was recorded as sparse, moderate or abundant. The presence or absence of new foliage was also recorded.

Ficus fruit characteristics were assessed for each species in the field by collecting either freshly fallen figs or from the tree itself. The fig diameter was measured to an accuracy of 0.1 mm using calipers. The weights of fresh figs were taken in the laboratory using scientific balance to an accuracy of 0.001 mg. The intraspecific and interspecific synchrony in ripening of figs were noted. The height and the diameter of tree crown were estimated visually. The DBH (density at breast height) was taken using measuring tape.

The different *Ficus* species in the site were categorised as uncommon, common and abundant based on population estimates. Infomations on fruiting characteristics of other fruiting plants were also documented though less systematically.

Birds

About One thousand four hundread hours was spent at Tenhipalam site between December 1989 and December 1992 while one thousand twenty eight hours was spent at Vythiri site between December 1990 and December 1992, monitoring avian foraging activity at different Ficus species.

Fruit-eating birds were recorded by direct observation. Only birds that swallowed entire fruits and that voided seeds intact were classified as frugivores (Snow 1971, Morton 1973). Birds that chewed fruits swallowing only the fruit pulps and dropping seeds below the parent plants were considered "fruit thieves" as they did not disperse seeds away from the plant (Howe and Estabrook, 1977).

The arrival and departure of avian visitors, and the method of fig handling by them were recorded. The following sampling techniques were used in the present study to quantify the avian foraging activity at every Ficus species.

1. Frequency of occurrence of each bird species ie; the number or percentage of occurrence of each species of bird in the bird activity census (Breitwisch 1979).
2. Frequency of visit ie; mean number of visit per hour by a bird species. Each visit is counted regardless of the number of conspecifics present. (Diamond & Terborgh 1967; Leck 1969, 1971; Howe 1977; Kantak 1979).
3. Length of Feeding bout or visitation length.
4. Rate of feeding ie; number of figs consumed per minute.

TABLE 5. **Fig eating bird species of Tenhjipalam Site** (Names follow Salim Ali, 1969)
(Bird species codes used in other tables are given)

Sl. No.	Code	Scientific Name	Common Name
1	2	3	4
		COLUMBIDAE	
1.	TP	Treron phoenicoptera chlorigaster (Blyth)	Common Green Pigeon
2.	TR	Treron pompadora affinis (Jerdon)	Greyfronted Green Pigeon
3.	TB	Treron bicincta bicincta (Jerdon)	Orangebreasted Green Pigeon
		PSITTACIDAE	
4.	RC	Psittacula cyanocephala cyanocephala (Linnaeus)	Blossomheaded Parakeet
5.	RP	Psittacula krameri manillensis (Bechstein)	Roseringed Parakeet
6.	LV	Loriculus vernalis rubropygialis (Stuart Baker)	Malabar Lorikeet
		CUCULIDAE	
7.	ES	Eudynamys scolopaeca scolopaeca (Linnaeus)	Indian Koel
		CAPITONIDAE	
8.	MN	Megalaima virdis (Boddaert)	Small Green Barbet
9.	MH	Megalaima haemacephala indica (Latham)	Coppersmith or Crimsonbreasted Barbet

Table 5 contd.....

1	2	3	4
		ORIOLIDAE	
10.	GO	Oriolus oriolus kundoo (Sykes)	Golden or Indian Oriole
11.	OX	Oriolus xanthornus maderaspatanus	Blackheaded Oriole
		STURNIDAE	
12.	AT	Acridotheres tristis tristis (Linnaeus)	Common Myna
13.	AF	Acridotheres fuscus mahrattensis (Sykes)	Jungle Myna
14.	SM	Sturnus malabaricus malabaricus (Gmelin)	Greyheaded Myna
15.	SP	Sturnus pagodarum (Gmelin)	Brahminy Myna
		CORVIDAE	
16.	CS	Corvus splendens protegatus Madarasz	House Crow
17.	CM	Corvus macrorhynchos culminatus (Sykes)	Jungle Crow
18.	DV	Dendrocitta vagabunda parvula (Kinnear & Whistler)	Tree Pie
		CAMPEPHAGIDAE	
19.	CN	Coracina novaehollandiae maeei (Lesson)	Large Indian Cuckoo-Shrike
		IRENIDAE	
20.	CA	Chloropsis aurifrons insularis	Goldenfronted Chloropsis

Table 5 contd....

1	2	3	4
		PYCNONOTIDAE	
21.	PC	Pycnonotus cafer cafer (Linnaeus)	Redvented Bulbul
22.	PJ	Pycnonotus jocosus fuscicaudatus (Gould)	Redwhiskered Bulbul
		MUSCICAPIDAE	
23.	TS	Turdoides striatus malabaricus (Jerdon)	Jungle Babbler
24.	TA	Turdoides affinis affinis (Jerdon)	Whiteheaded Babbler
25.	ZC	Zoothera citrina cyanotus	Whitethroated Ground Thrush
26.	CR	Copsychus saularis ceylonensis	Clater's Magpie Robin
		DICAEIDAE	
27.	DE	Dicaeum erythrorhynchos erythrorhynchos (Latham)	Tickell's Flowerpecker

5. Fruit removal rate, ie; the mean number of figs eaten or removed by each species of bird in a hour of observation.
6. The time budget analyses for major frugivores ie; pattern of allocation of time by a bird in various behavioural activities during foraging (e.g. Enoksson, 1983, Bryant and Tatner 1988).
7. Technique of fruit handling and foraging patterns.
8. Foraging heights and sites within a feeding tree.

All activities were monitored by focal animal sampling (Altmann 1974). The focal individual was closely followed and recorded. Various activities were timed using digital and stop watches.

A feeding bout began when a bird entered or alighted on the fruiting *Ficus* crown and picked up and consumed fig and it continued as successive figs were eaten. It ended when a given fruit was discarded or totally consumed and then left or if no other fruit was taken within next 5 minutes (Bonaccorso et al. 1987). The visitation length was ascertained by recording times of entry and departure from the fruiting plant or if the feeding was followed by a pause of more than 5 minutes.

Data on feeding rates were collected by two methods; (1) counting the number of figs consumed by the focal individual during each visit when it was possible to monitor the bird without interruption, or (2) counting the number of figs consumed by the focal animal for a minumum of 10 minutes duration it it was difficult to monitor the focal bird which disappeared in the foliage. The fruit removal rate for each fugivore species was estimated as the product of means of visitation length, visitation rate, feeding rate and group size of each species of bird.

For time budget study the behavioural activities expressed by the focal bird were closely monitored and each activity was timed for 10 minutes intervals. The time spent in each activity was expressed as percentage of the total time of observation (Enoksson 1987). The following behavioural categories were recognised; foraging (includes movement, searching and picking and eating figs); perching (resting); preening; flight or locomotion (other than for feeding and defence of territory); agonistic encounters (intraspecific and interspecific); courting; cleaning bill etc.

The nature of fruit intake was recorded as either swallowing or piece-meal diet. The angle of feeding used in plucking figs were distinguished as 'head down' or 'hanging down' position and 'reach' position. (Sorensen, 1983). The use of "hovering" or 'flight' tactics to pick up figs was also noted. The foraging and movement patterns were recognised as "widely foraging" and 'sit-and-wait foraging types using various movements like 'hop', 'walk'and 'flight' across the tree canopy.

Plate 4. Cardamomum cultivation at Vythiri site.

Plate 4.

The four foraging branch site categories used by various bird species were recognised according to their diameter; branch 1 (up to 1 cm), branch-2 (1 cm to 2 cm), branch 3 (2 cm to 3 cm), branch-4 (above 3 cm diametre). The foraging branches were assigned to respective category visually after sample measurements. The foraging zones or heights on a tree were recognised as upper branch, middle branch and lower branch from visual estimates. (Porter et al. 1985).

The observation periods usually lasted 4 to 6 hours and were timed to sample different periods of the day. For each tree species, each hour of the day between approximately 0630 hr and 1830 hr was equally utilised. Repeated observations were done on a number of individuals of each tree species to avoid bias from the influence of microhabitat of the plant on avian utilisation.

Data were collected for different frugivores species during periods of peak ripe-fruit production. The variation in hours of observation per Ficus species was either due to relative success in locating suitable tree; to how long they stayed in fruit and to difference in the abundance of each species. Some Ficus species bore figs in alternate years only.

All quantitative data on behavioural acivities for most frugivores at each tree species were collected during different days

TABLE 6. **List of avian frugivores attending fruiting *Ficus* in the Vythiri area.**
Code names are also given.

Sl. No.	Code	Scientific name	Common name
1	2	3	4
		COLUMBIDAE	
1.	TR	*Treron pompadora* affinis (Jerdon)	Greyfronted Green Pigeon
2.	DB	*Ducula badia* cuprea (Jerdon)	Imperial Pigeon
		PSITTACIDAE	
3.	BP	*Psittacula columboides* (Vigors)	Bluewinged Parakeet
4.	LV	*Loriculus vernalis rubropygalis*	Malabar Lorikeet
		BUCEROTIDAE	
5.	TG	*Tockus griseus griseus* (Latham)	Malabar Grey Hornbill
		CAPITONIDAE	
6.	MV	*Megalaima virdis* (Boddaert)	Small Green Barbet
7.	MR	*Megalaima rubricapilla malabarica* (Blyth)	Crimsonthroated Barbet

1	2	3	4
		ORIOLIDAE	
8.	GO	*Oriolus oriolus*	Golden Oriole
		STURNIDAE	
9.	GR	*Gracula religiosa*	Hill Myna
10.	SB	*Sturnus malabaricus blythii* (Jerdon)	Blyth's Myna
		IRENIDAE	
11.	CA	*Chloropsis aurifrons insularis*	Goldenfronted chloropsis
12.	IP	*Irena puella puella*	Fairy Bluebird
		PYCNONOTIDAE	
13.	PJ	*Pycnonotus jocosus fascicaudatus*	Redwhiskered Bulbul
14.	HM	*Hypsipetes madagascariensis ganeesa* (Sykes)	Black Bulbul
15.	HI	*Hypsipetes indicus indicus* (Jerdon)	Yellowbrowed Bulbul
		MUSCICAPIDAE	
16.	ZC	*Zoothera citrina cyanotus*	Whitethroated Ground Thrush

1	2	3	4
17.	MC	*Monticola cinchlorhyncus* (Vigors)	Blueheaded Rock Thrush
18.	MS	*Monticola solitarius* pandoo (Sykes)	Indian Blue Rock Thrush
19.	LW	*Phylloscopus trochiloides viridanus* Blyth	Green leaf Warbler
20.	TM	*Turdus merula bourdilloni* (Seebohm)	Black Bird
		PARIDAE	
21.	PX	*Parus xanthogenys travencorensis*	Travancore yellowcheeked Tit
		DICAEIDAE	
22.	DE	*Dicaeum erythrorhyncos erythrorhyncos* (Latham)	Tickell's Flowerpecker
23.	DC	*Dicaeum concolor concolor* (Jerdon)	Nilgiri Flowerpecker
		ZOSTEROPIDAE	
24.	ZP	*Zosterops palpebrosa nilgiriensis* (Ticehurst)	Nilgiri White-eye
		FRINGILLIDAE	
25.	CE	*Carpodacus erythrinus roseatus* (Blyth)	Common Indian Rosefinch

of the study period. This was necessary since a single observer could not make all essential observations on one day. For a few *Ficus* species which were poorly represented in study areas, adequate informations had to be gathered from observations made at nearby places at similar fruiting figs.

All statistical calculations except when noted were non-parametric (Siegel, 1956). Chi-square test was used to test the significances of frguency of occurrence, success rates, fruit removal rates, etc. of different bird species (Howe 1977) Mann-Whitney- U test was used to compare visitation length and feeding rates of various birds and one-way ANOVA was used for time-budget analyses. The foraging site dependence of bird species was assessed using RUNS test. (Porter et al. 1985). Most analyses were run using SPSS/MSTAT computer packages (Nie et al. 1975).

TABLE 7. **Frugivore specialists/opportunists and Residential status (Tenhipalam site)** (R = Resident, LM - Local Migrant, M - Migrant)

Sl. No.	Bird Taxon	Residential Status
1	2	3
	Specialists	
1.	*E. scolopacea*	R
2.	*M. virdis*	R
3.	*M. haemacephala*	R
4.	*T. phoenicoptera*	LM
5.	*T. pompadora*	M
6.	*T. bicincta*	M
7.	*P. cyanocephala*	R
8.	*P. krameri*	R
9.	*L. vernalis*	LM
10.	*P. cafer*	R
11.	*P. jocosus*	LM
	Opportunists	
12.	*C. macrorhynchos*	R
13.	*C. splendens*	R
14.	*A. tristis*	R
15.	*A. fuscus*	LM
16.	*S. pagodarum*	R

Table 7 contd.....

1	2	3
17.	S. malabaricum	M
18.	O. oriolus	M
19.	O. xanthornus	R
20.	D. vagabunda	R
21.	D. novaehollandiae	LM
22.	T. striatus	R
23.	T. affinis	R
24.	D. erythrorhynchos	R
25.	Z. citrina	R
26.	C. aurifrons	R
27.	C. saularis	LM

TABLE 8. **Frugivore specialists/opportunists and Residential Status (Vythiri site)**

Sl. No.	Bird species	Residential Status
1	2	3
	Specialists	
1.	*T. pompadora*	R
2.	*D. badia*	R& LM
3.	*P. columboides*	R
4.	*L.vernalis*	LM
5.	*T. griseus*	R
6.	*M. virdis*	R
7.	*M. rubricapilla*	R
8.	*P. jocosus*	R
9.	*H. madagascariensis*	R & LM
10.	*H. indicus*	R
11.	*T. merula*	LM
12.	*C. erythrinus*	M
	Opportunists	
13.	*G. religiosa*	R
14.	*S. malabaricus blythii*	LM
15.	*C. aurifrons*	R
16.	*I. puella*	LM
17.	*Z. citrina*	R

Table 8 contd....

1	2	3
18.	*M. cinchlorhynchus*	M
19.	*M. solitarius*	M
20.	*Phylloscopus trochiloides*	M
21.	*P. xanthogenys*	R
22.	*D. erythrorhynchos*	R
23.	*D. concolor*	R
24.	*Z. palpebrosa*	R & LM
25.	*O.oriolus*	M

FRUTING PHENOLOGY OF FICUS SPECIES

T. N. Vijayakumar "Resource utilization by birds attending figs in South India" Thesis. Department of Life Sciences , University of Calicut, 1994

CHAPTER 3

FRUTING PHENOLOGY OF *FICUS* SPECIES

a) *Ficus tsjahela* Burm. f.

The *F. tsjahela* is commonly seen in the evergreen forests of India. It has been reported in Asia, New Guinea and Australia (Corner, 1965). It is widely grown in cardamum plantations and also along the country sides as shady trees. The species is monoecious.

Fruiting Phenology

The phenológical studies were carried out in the two plants located in the Tenhipalam area. The trees were 7 m to 25 tall, 1 m - 2 m girth and having a crown of 10 m - 12 m diameter. The figs were very small with a mean diameter of average. 4.5 mm. They were round and sessile, and arising in pairs at the axils of fallen leaves mostly along the 1/3 of the length from tip of the small terminal pendant twigs, or along the small branches. The figs were dull white when ripe and less juicy. The majority of figs in a crop were at the same stage of development exhibiting high intra-crop synchronization of fig-ripening.

Usually a particular tree flowered and produced fruits 3 to 4

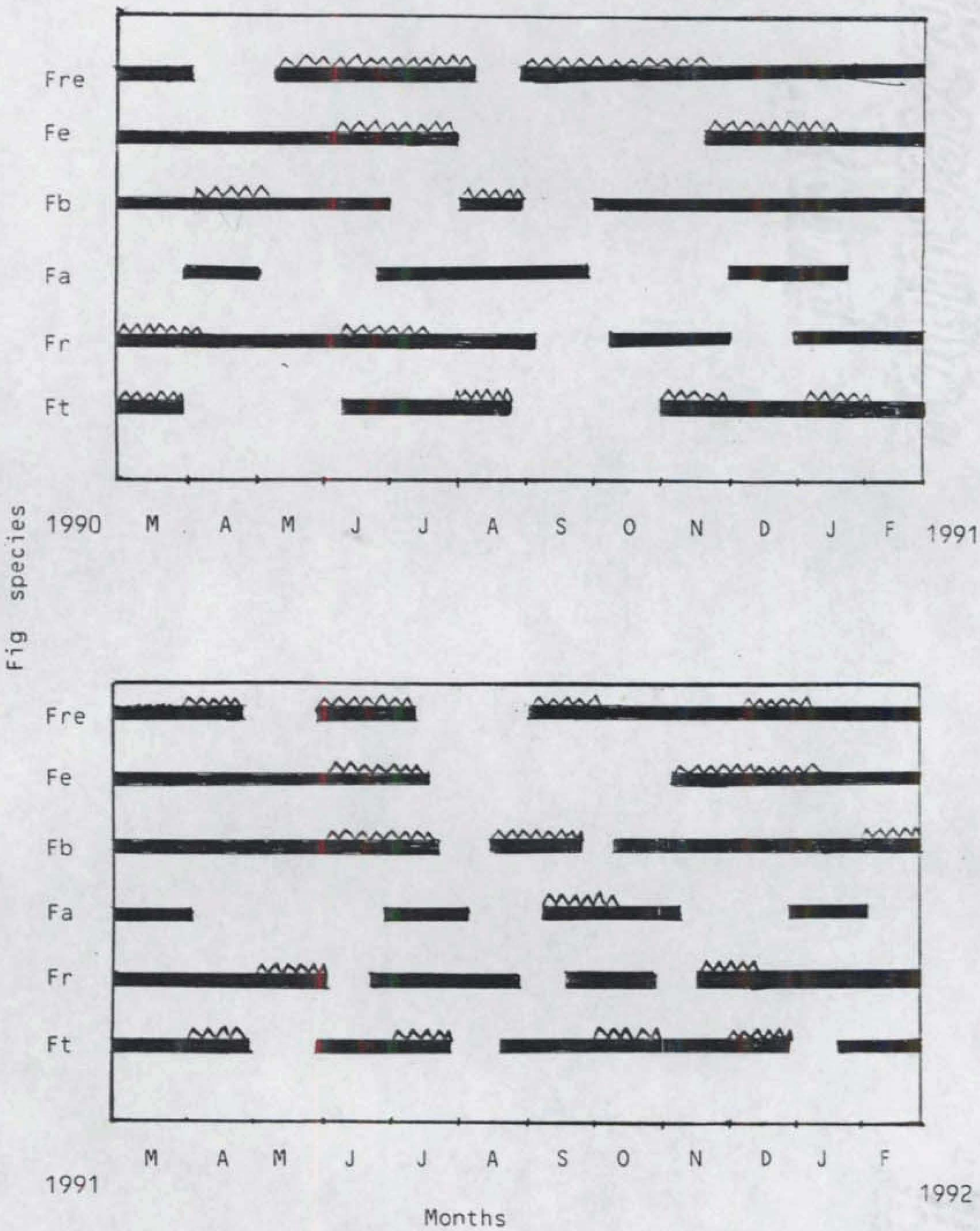
Fig. 2. Seasonal availability of ripe figs of six _Ficus_ species in the Tenhipalam site (a) during 1990-91 (b) during 1991-92

Fre - _Ficus racemosa_; Fb - _Ficus benghalensis_

Fe - _F. exasperata_; Fr - _F. religiosa_;

Fa - _F. amplissima_; Ft - _F. tsjahela_

(Astrix on band shows sparse availability).


Fre
Fe
Fb
Fa
Fr
Ft
1990
M
A
M
J
J
A
S
O
N
D
J
F
1991
Fig species
Fre
Fe
Fb
Fa
Fr
Ft
M
A
M
J
J
A
S
O
N
D
J
F
1991
1992
Months

times annually. The figs were produced in great abundance in every crop. The fruiting was found to be aseasonal with each plant bearing figs in the dry, winter and wet seasons. No interindividual synchronization of fruit production was observed in the two plants of the area of present study. The species defoliated usually twice a year.

Ficus tsjahela is also a common species of fig in the Vythiri site. Its population consisting of 12 plants included relatively small and young trees to older and much taller ones. The height of the trees ranged between 20 and 30 m with DBH ranging between 1.5 and 5 m. The diameter of the crowns measured upto 15 to 18 m in some individuals.

The flowering and fruiting characteristics and the various morphological features of figs were same as that described for the same species in the study area 1. Each plant bore 3 to 4 crops annually and though the fruiting occurred in all seasons, its peak was in the dry season spread between October and May (Fig. 3).

b) *Ficus microcarpa* Linn. f.

Distribution

Ficus. microcarpa is a large evergreen tree, species widely distributed throughout the South East Asia, occurring indigenously in

Sri Lanka, India, South China, Ryaku Island, eastwards through S.E. Asia and Malyasia to New Britain and Australia and Hongkong (Corner, 1965; Hill, 1967).

Fruiting Phenology

The phenological observations were carried out in the eleven plants of this species located in the Vythiri area. The plants were moderate to large in size. The height of trees in the population varied between 20 m to 30 m and the diameter at breast height ranged ranged between 2 m to 5.5 m. Many of the plants had buttress growth.

The syconia were small, globose or sub-globose in shape with a mean diameter of 9.9 mm. They were auxilliary and produced singly with pairs and were borne towards the tip of small twigs forming small clusters. The ripe figs were bright yellow to orange red in colour. An individual tree produced one or two crops annually. Figs were produced in great abundance. A large proportion of this crop was found aborted or whithered at half-maturity.

Fairly high intra-plants synchronization of ripening of figs was observed. The defoliation of older leaves occurred simultaneous with fresh foliage production. So the tree was never completely leafless during any time in an year. As individual tree had one to two flushes in an year.

The fruiting was rather irregular and the species bore fruit in most of the months of the year (Fig. 3). However, the dry seasons extending between September and March was the peak fruiting period.

c) *Ficus religiosa* Linn. (Indian Peepul tree)

A large shady tree, widely planted in the country sides and also in temple premises. The species was reported to be growing in Sub-Himalayan forest from Rawalpindi to Yunnan, Indo China and North Thailand (Corner, 1965).

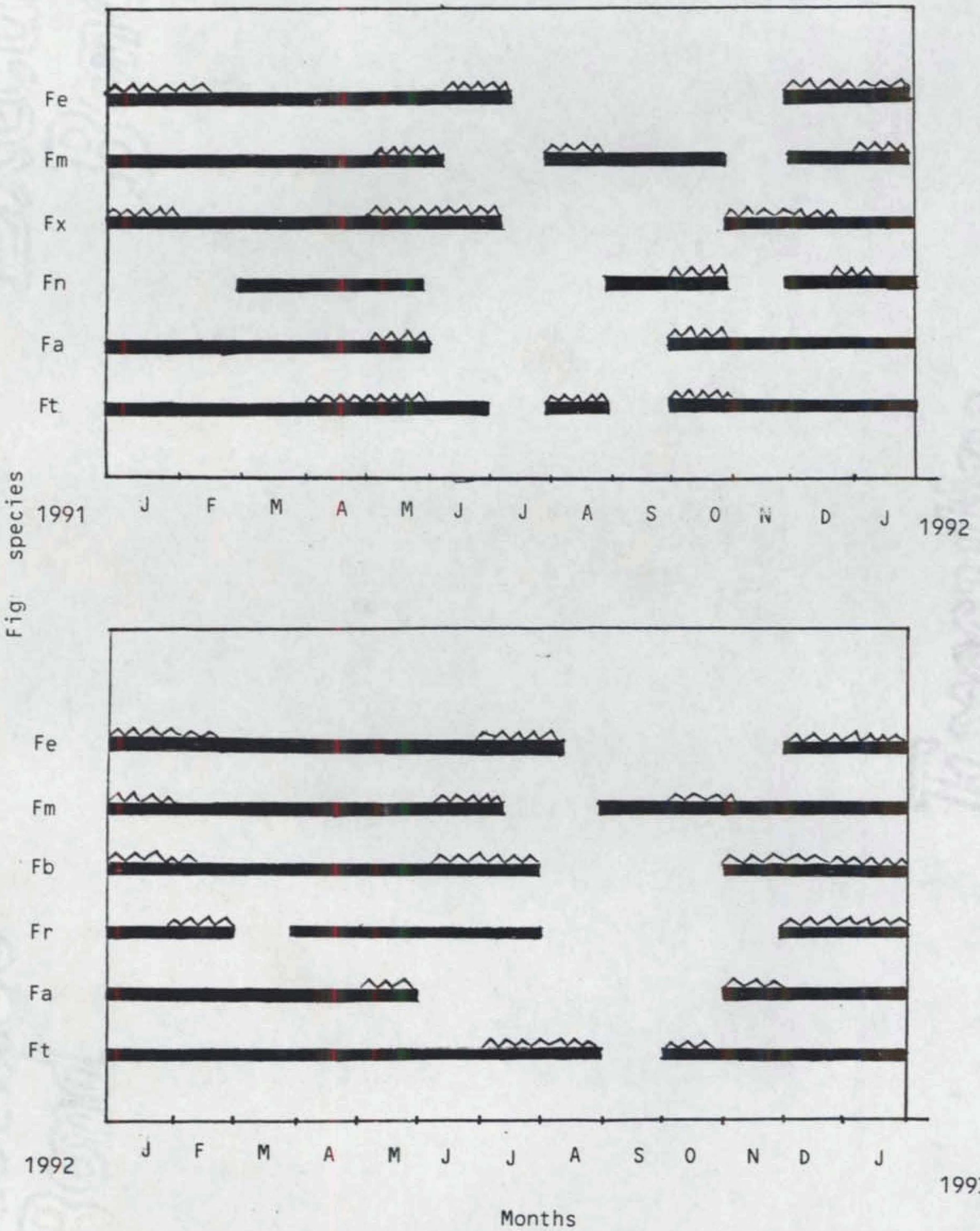
Fruiting Phenology

Six trees of *F. religiosa* were selected for the phenological studies in the Thenhipalam study area, They were moderate to large sized trees, 15 m to 35 m tall, 1.5 m to 4 m DBH and having a crown of 7 m to 15 m diameter.

The syconia were medium sized (11.10 $\pm$ 1.2 mm diameter), sessile globose or subglobose in shape. They were borne in pairs usually arising at the axils of fallen leaves. The ripe figs were dark purple in colour and were very soft and juicy. The fairly ripe figs had poor persistence and at slightest disturbance by wind or bird movement. Usually an individual tree produced 1 to 2 crops annually.

Fig. 3. Seasonal availability of ripe figs of six *Ficus* species in the Vythiri site (a) during 1991-92 (b) 1992-1993. (Astrix on band shows sparse availability).

Ft - *Ficus tsjahela*; Fa - *F. amplissima*; Fn - *F. nervosa*; Fbe - *F. beddomei*; Fm - *F. microcarpa*; Fe - *F. exasperata*



Fe
Fm
Fx
Fn
Fa
Ft
1991
J F M A M J J A S O N D J
1992
Fig species
Fe
Fm
Fb
Fr
Fa
Ft
1992
J F M A M J J A S O N D J
1993
Months

The flowering and fruiting was generally aseasonal and spread irregualrly in the population (Fig.2). However, there was a peak fruiting period in the population during the months from October through March, when majority of the members bore fruits. Being deciduous the species defoliated twice in an year. The first shedding process was staged prior to the summer flowering and fruiting episode. The fresh foliage sprouted in a week or two.

The figs in a plant ripened synchronously while the interindividual synchrony was not much observed, and the different plants fruited at different times during the period of observation.

d) *Ficus amplissima* J.E. Sm.

A common wild variety of fig found in the evergreen forest and also cultivated as shady trees along the country sides of South India. Corner (1965) has reported the occurrence of this *Ficus* sp. in peninsular India (Central provinces and Southwards), in Sri Lanka and Maldive Islands.

Fruiting Phenology

Three trees of *F. amplissima* growing in the Tenhipalam site were included in the present study. They were relatively young plants of small to moderate size. One of these trees was then growing as

Plate 5. _Ficus microcarpa_ plant at Vythiri site.

Plate 5

strangler around a Macaranga peltata tree. The trees were 12 m - 20 m tall, 0.5 m -1.5 m in girth and having a crown of 6 m - 13 m diameter.

The abundant crop consisted of medium sized figs (x 13 mm $\pm$ 1.4 mm diameter), which were more or less spherically shaped. They were borne in pairs at the axils of falling or fallen leaves and were often produced towards the tip of small terminal twigs of about 1 cm diameter. It has been noted that the defoliation commenced either by the time of flowering or after the commencement of flowering and sometimes it occurred only after the fruiting episode. The tree remained bare and leafless for 2 to 3 weeks. The bare tree with full of figs in terminal clusters attracted several avaian foragers. The new flushings appeared by the time figs were ripe. The figs changed from green to pale white to dull pinkish to black coloured when fully ripe. The partially ripe dull coloured figs flecked with black dots were eaten by the frugivores. The fruit production was estimated to be ca. 1,00,000 to 2,00,000 numbers per tree of present study.

Usually the trees fruited 1 to 2 times in an year. Two of the trees studied produced 2 crops while the third and the youngest one bore only a single crop per year during the study period between 1989 and 1992. In the tree which fruited twice in an year, the first crop appeared in July through September and the second one occurred between November and January. Most of the fruits in a plant ripened synchronously. No intra - specific or inter-individual synchrony in fruit production was observed among the three plants of the present investigation.

The population of F. amplissima in the Vythiri site consisted of 22 plants. Of these only 16 plants were considered for the phenological observations. The trees were moderate to very tall with 20 to 35 m heigh, 3 to 5 m DBH. Some plants had buttress growth. The branches were widely spread and tree canopy had diameter ranging from 10 m to 20 m.

The flowering and fruiting characteristics and other morphological features of figs were as described for the same species in the Tenhipalam site. However, the flowering and fruiting were found to be more seasonal and the plants were in flower and figs in the dry season extending from October through April (Fig 3).

d) Ficus benghalensis Linn.

Distribution

This species is characterised by very large trees with multiple buttressed trunks supporting dense canopy and widely spreading surface roots. They are indigenous to India and Pakistan (Corner, 1965). Hill (1967) has reported the species from Hongkong. They were grown as common shady trees along the country sides, and with religious sanctity in temple premises.

Fruiting Phenology

The F. benghalensis was one of the commonest variety of fig species in the study area I. There were 18 of them growing in the site. In the trees with buttress growth, the girth measurements were taken just above it. The crown of most trees were well spread with 8 m to 20 m diameter.

The synconia were globose or sub-globose in shape, sessile and relatively large in size measuring 15 mm to 23 mm diameter. They arise in pairs at leafy axils usually towards the tip of terminal twigs where they formed small clusters of 6 to 8 figs with adjacent pairs of figs. The fully ripe fruits were orange red to scarlet red in colour. Usually the trees flowered one to two times in an year. Some trees even produced a third crop. The fruiting and defoliation were rather irregular and the population contained fruiting plants almost throughout the year (Fig. 2). In 1990 the ripe figs were available in all months except in July and September. However, a peak fruiting period has been observed from October through March in the pupulation. The fruits were relatively very persistent. The crop density has been estimated to be about 50,000 to 1,00,000 per tree.

The defoliation occurred two to three times annually. The fresh foliage appeared more or less simultaneously with the shedding of often leaves. Though there were considerable intra-plant synchrony in the ripening of figs, the inter-plant synchrony was not so prominent. However, two trees each produced fruits almost simultaneously in the months of November, January, February and March in 1991. It has been noted that the synchronously flowered and fruited plants were growing at distance apart. The adjacent or nearby trees invariably flowered at different times. No consistency in the sequence of fruiting among different plants in the population were observed. The tree which flowered (first) in one year, flowered at another time in the following year.

e) *Ficus exasperata* Vahl.

Ficus. *exasperata* is moderate sized tree, well distributed in wild habitats in central and South India along river banks and also in the country sides. Corner (1965) has reported their distribution in East Africa, Asia and Sri Lanka.

Fruiting Phenology

Another very common fig species in the site-1 with a population of 16 trees of small to moderate size. They are 5 m to 20 m tall, with 0.25 m to 1 m DBH. The canopy diameter ranged between 3 m and 12 m.

The flowering and fruiting was fairly seasonal and occurred in the post-monsoon or dry season from October through April or May. The first tree in the area flowered towards the end of October in 1990. The first set of ripe figs were borne by mid-December. The fruiting in the population reached its peak during the dry summer months of February through April or May. (Fig2 & 3). However, the ripe figs were available at least in one plant till the end of June.

Most of the plants under study produced only one crop sequence in an year. However, some plants borne 2 sequence of crops. Then the first flowering and fruiting sequence was found to be sparse to moderate sized. The second sequence of synocia which was initiated simultaneous with the ripening of the first crop was more abundant.

The figs of *F. exasperata* were relatively large with diameter ranging between 18 mm and 25 mm. The pedunculate figs were solitary and axillary. They changed from green to yellow to red or reddish brown when ripe. The fully ripe or over-ripe reddish brown figs had fallen very easily. The, relatively small sized crop ranged between 2,500 and 30,000 figs in the plants of the area of present study. There was reasonably a good intra-tree synchrony of fruit-ripening.

Plate 6. A. Bunches of figs borne special small branches or spikes or *F. racemosa*. Figs are ripening.

B. Figs produced in terminal clusters on leafless twigs of *F. amplissima*.

PLATE 6

A

B

The trees of this deciduous species defoliated once a year. The shedding of old foliage usually commenced simultaneous with the initiation of flowering. By the time the figs got matured, the tree become bare. This condition persisted for 3 to 4 weeks and the fruit-ridden tree with bright yellowish figs attracted several frugivore dispersal agents.

The Ficus exasperata was also a very common species at Vythiri site with a population of 16 plants. The phenological observations were conducted only on 12 selected plants. The other plants were discarded for inconveniences in observaions. All the plants studied were relatively young and small trees ranging from 0.8 m to 15 m in height, 0.50 m to 1.25 m DBH. The diameter of the foliage crown ranged between 5 m to 12 m.

The flowering and fruiting patterns were almost similar to the conspecific trees in the study area I. The morphological features of figs were also almost the same. An individual plant produced one or two sequences of crops. The second sequence appeared when the figs of the first crop were ripening. The flowering was quite seasonal and it commenced in November/December (dry season). Most of the trees in the population were in ripe figs during January through May (summer months). A peak in fruiting was, however, observed in May as noticed during the period of study (Fig. 3). The crops on some plants extended through the monsoon months, June through August, though rather sparsely in August.

A good within-tree synchronization and relatively greater inter-individual and intra-specific synchronization in ripening of figs were observed in this species. six to seven plants had simultaneously ripening crops during the 2 year study period between Jan 1991 and December 1992.

f) *Ficus racemosa* L.

Distribution

Corner (1965) has reported this fig species from Sri Lanka, Pakistan, India, South China to Sumatra, Lesser Sunda 1st. (Alor), South Celebes, New Guinea and Australia. They are grown in the moist deciduous forest habitats as also well distributed along country sides. They grow to moderate sized trees and are deciduous.

Fruiting Phenology

Six of these plants were located in the Tenhipalam site. All were independent trees of small to moderate size ranging from 5 m to 12 m in height, 0.25 m to 0.50 m in diameter at breast height, and 5 m to 8 m in crown diameter.

The figs measured 2 to 3 cm in diameter and were borne in large clusters of 40 to 60 figs,(Plate 6) either on short special leafless spikes or twigs arising from branches or trunks or the main trunk itself. The figs were pedunculate. As it ripened the individual syconium or fig changed from green to yellow to orange red or pink coloured. The fully ripe figs were very soft and juicy. Due to the poor persistence, these full ripe figs were readily dropped at slightest disturbance from wind or rain or forager movement. Most of the crops were so dropped to the ground which were later eaten by the grazing mammals.

An individual F. racemosa tree flowered five to six times in a year. Most of the trees were without crop only for a very small period of the year. A fresh fruiting sequence was often initiated while some of the figs from the previous crop were still on the tree. The monsoon crop appeared in May through July was sparse to moderate. Most of this crop when ripe were withered or decayed and dropped.

There was a fairly high within tree synchronization of fruiting with over 50 percent of the crop ripening simultaneously. The intraspecific synchronization of ripening of fruits was poor and was observed in only a few cases. Two of the trees which were quite close to each other often produced synchronous crops. Four trees were found producing synchronized crop in June 1990.

Plate 7. a. A leafless *F. exasperata* plant in full bloom of Golden yellow coloured figs.

b. A young *F. amplissima* tree in fresh foliage at Vythiri site.

PLATE 7

a

b

The species was deciduous and defoliation occurred two to three times a year. The shedding of old foliage in dry months occurred more or less simultaneous with the appearance of new flushings while most of the trees during monsoon withered their foliage following the fruiting episode and remain leafless for 2 to 3 weeks. No consistency in fruiting sequence was however observed in 1990 and 1991. An individual tree initiated and produced figs at different times.

g) *Ficus nervosa* Heyne Ex. Roth

An evegreen species usually growing with a large single trunk. It is monoecious. This species is indigenous to India, Sri Lanka, Burma, and China (Kueichow, Kwangtung, and Hainam, Hong Kong, Indochina and Taiwan).

Fruiting phenology

Seven trees of this species were marked in the Vythiri study area. They were tall independent trees with about 30 m - 35 m height and 1.5 to 4 m DBH and having a canopy of 10 to 15 m diameter. The trees defoliated once in an year. The new foliage was produced simultaneous with defoliation. Though, one tree had two equally developed trunks, each of them acted as two independent trees bearing flower and fruits at different times.

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TABLE 9. **Ficus species studied with their fig characteristics** (Plants are arranged in the increasing order of their fig sizes)

Ficus spp.	Fig size (mean diameter in mm)	Colour of ripe fig	NO. of trees observed in Site I	Hours of obser-vation	No. of trees observed in Site II	Hours of obser-vation
F. tsjahela	4.54 ± 0.58	Dull white	2	96	13	123
F. elastica	6.61 ± 0.35	Pink	1	26	--	--
F. superba	8.28 ± 1.06	White	1	31	--	--
F. gibbosa	9.11 ± 6.81	Yellow or orange red	2	31	--	--
F. microcarpa	9.91 ± 1.33	Yellow or orange red	3	42	12	117
F. religiosa	11.10 ± 0.12	Purple brown	6	134	--	--
F. amplissima	13.03 ± 1.38	White/dull black	3	104	18	155
F. benghalensis	18.70 ± 1.80	Red or Orange red	18	204	--	--
F. exasperata	19.60 ± 0.38	Yellow, red brown	16	150	14	108
F. nervosa	20.22 ± 2.82	Orange, red or Pink	--	--	8	104
F. racemosa	23.90 ± 3.01	Pink or brown	6	97	--	--
F. beddomei	23.94 ± 5.54	Dull yellow	--	--	22	136

The figs were axillary in pairs or single and non-pedunculate. They were round or globose in shape and relatively large sized with a diameter ranging from 16 mm to 29 mm. The immature figs were green coloured and they became yellow to orange red to Crimson red in colour at ripeness. The poorly ripe and partially ripe figs were having relatively hard pericarp. it turned soft and fleshy or more Juicy when fully ripe. These ripe fruits were seen to be having poor persistence and were detatched easily from the tree at slighter disturbance. So the plant lost more figs below the tree than were dispersed by frugivorous animals as in the case of F. beddomei. Several immature or partially ripe figs were also found to be aborted in a profusely fruited tree.

The flowering and fruiting were irregular in F. nervosa. This species bore figs in dry as well as in wet seasons (Fig. 3). However, the flowering and fruiting were more prominent in the dry summer months. It has been noticed that most of the trees under present investigation had produced figs only once in a period of two years between December 1990 and December 1992.

h) Ficus beddomei King

Distributions

A monoecious large evergreen species. Corner (1965) has reported it to be an endemic species of South India (Nilgiri, Anamalai, Tirunelveli Hills). It is well represented in the present study area at Vythiri.

Fruiting Phenology

The phenological observations on the fruiting characteristics of F. beddomei were carried out on the 22 plants located in the Vythiri site. All were tall independent trees reaching to a height of about 20 to 35 m and of 3 to 4.5 m DBH. The thick canopy formed by glabrous large leaves, has a diameter of 10 to 18 m. Some of the trees had buttress growth. This species defoliated the foliage once in an year. New foliage often developed simulataneous with defoliation.

Figs turned soft and fleshy only at full ripeness. They were borne in pairs at the axils of leaves towards the tip of terminal twings. The adjacent pairs of figs formed small clusters of 4 to 10 figs. The ripe figs were dull yellow coloured and had a very poor persistance. They were easily dropped at slightest disturbance by wind or forager movements.

Each tree flowered and fruited usually once in an year. Some of them, however, produced two sequences of crops. In these trees, the

Plate 8. *Ficus nervosa* in fruits at Vythiri site.

Plate 8

second sequence of flowering was initiated while the figs of the first crop were getting ripe. The flowering was seen to be more seasonal and all the fruit producing trees flowered in the dry season. During both the years of study between December 1990 and December 1992, the flowering commenced in September/October months. However, the ripe fruit production extended upto July and August (Fig. 3).

A peak in ripe fig production was observed in March during both the years of study. There was greater intra-tree synchronization of fruit ripening. 5 to 6 trees were found to produce ripe figs almost simultaneously showing a low degree of inter-tree synchronization.

AVIAN FRUGIVORE ASSERBLAGE AND DAILY ACTIVITY

T. N. Vijayakumar "Resource utilization by birds attending figs in South India"
Thesis. Department of Life Sciences , University of Calicut, 1994

CHAPTER 4

AVIAN FRUGIVORE ASSEMBLAGE AND DAILY ACTIVITY

Twenty seven species of birds belonging to eighteen genera in thirteen families utilized figs in the Tenhipalam study area (Table 5). During the study period between December 1989 and December 1992 a total of one hundred and five bird species were recorded here (Appendix 3). The fig-eating avian community included mainly insectivore species like Magpie-robin (*Copsychus saularis*) and phytophagous fruit pigeons of *Treron* species. Table 10 describes the list of birds associated with ten *Ficus* taxa and table 7 gives the residential status of the different frugivore species.

The fruit-eating specialists, namely, the Koel (*E. scolopacea*), the Common Green Pigeon (*T. phoenicoptera*), the Small Green Barbet (*M. virdis*) and the Coppersmith Barbet (*M. haemacephala*) regularly ate figs of all sizes (Table 10). Similarly, the fruit-eating opportunists like the Common Myna (*A. tristis*) and the Golden Oriole (*O. oriolus*) consumed figs of all fig species studied.

Of the important fig-eating species, the Common Green Pigeon was found to be nomadic and was absent in the Tenhipalam site during July through October. Then it was a lean period of fruit production for figs as well as for many other fruiting plants in this study area. The Grey headed Myna and the Golden Oriole were migrants arriving here by the end of October and departing by mid-April. They were opportunistic fruit-eaters. The Greyfronted Green Pigeon appeared in the area towards the end of May and departed by August. Hence they were monsoon migrants. The third fruit pigeon, the Orangebreasted Green Pigeon (Treron bicincta) came as a transient migrant during January-February period in 1991.

In the Vythiri study area, of the one hundred and forty six species of birds recorded (Appendix 4), the fig crops were consumed by twenty five different bird species belonging to twentyone genera in thirteen families (Table 6).

The important fig consumers were the frugivore specialists like Greyfronted Green Pigeon (T. pompadora), Malabar Grey Hornbill (Tockus griseus), Imperial Pigeon (Ducula badia), Barbets (M. virdis and M. rubricapilla), Bulbuls (Pi. jocosus, Hypsipetes madagascariensis, H. indicus etc.) and opportunists such as Hill Myna (Gracula religiosa), White Eye (Zosterops palpebrosa), Blue bird (Irena puella) etc.

Table 8 describes the residential status of various frugivores attending figs in this area. Majority of bird species were residents. Some of them made local movements in different seasons depending on the availability of fruit resource. The Golden Oriole, Blue Rock Thrush, Blue-headed Rock Thrush etc. were winter migrants.

A. Thenhipalam Site

Frequency of occurrence

The avian frugivore assembly and their foraging activities on the fruiting crown of *F. benghalensis* were observed for a total duration of 160 hours during the three year study period. Altogether 335 bird activity censuses were carried out at this fig species. Twentyfour species of frugivorous birds visited this fig tree (Table 10). Of these ten species were fruit-eating specialists such as common Green Pigeon, Koel, Small Green Barbet, Coppersmith Barbet, Blossomheaded Parakeet, Roseringed Parakeet, Redwhiskered and Red-vented Bulbuls.

The opportunistic visitors included the Jungle Crow, House Crow, Common Myna, Brahminy Myna, Greyheaded Myna, Golden Oriole etc. (Table 10).

The frequencies of occurrence of Seventeen species of birds were estimated and are given in the table 12. Those species having less than 5% attendance were not considered in this study. The specialised frugivores had significantly greater frequency of occurrence than the oppotunists ($X^2 = 9.93$, $P < 0.01$).

TABLE 10. **Avian feeding assemblages of _Ficus_ species of Tenhipalam site**

Bird species codes used according to table 5

	Ficus spp.	TP	TR	TB	RC	RP	LV	ES	MV	MH	GO	OX	AT	AF	SM	SP
1.	_F. tsjahela_	X	X	-	X	-	-	X	X	X	X	X	-	-	X	-
2.	_F. microcarpa_	-	-	-	X	X	-	X	X	X	X	-	X	-	X	-
3.	_F. elastica_	-	-	-	-	-	-	X	X	X	X	-	-	-	-	-
4.	_F. superba_	X	X	-	-	-	-	X	X	X	-	X	X	-	-	-
5.	_F. gibbosa_	-	-	-	X	-	-	X	X	X	X	-	-	-	X	-
6.	_F. religiosa_	X	X	X	X	X	X	X	X	X	X	X	X	-	X	X
7.	_F. amplissima_	X	-	-	X	X	-	X	X	X	X	X	X	X	X	-
8.	_F. benghalensis_	X	X	-	X	X	X	X	X	X	X	X	X	-	X	X
9.	_F. exasperata_	X	X	-	-	-	-	X	X	X	X	X	X	X	X	X
10.	_F. racemosa_	X	X	X	-	-	-	X	X	X	X	-	-	-	-	-

contd.....

Table 10 contd.....

	CS	CM	DV	CN	CA	PC	PJ	TS	TA	ZC	CR	DE
F. tsjahela	-	X	-	X	X	X	-	X	X	X	-	X
F. microcarpa	-	X	X	-	-	-	-	-	-	-	-	X
F. elastica	-	X	-	-	-	X	-	-	-	-	-	-
F. superba	-	-	X	X	-	X	-	X	X	-	-	-
F. gibbosa	X	X	-	-	-	-	-	-	-	-	-	X
F. religiosa	X	X	X	X	-	X	X	X	X	X	X	X
F. amplissima	X	X	X	-	-	X	X	-	-	-	-	X
F. benghalensis	X	X	X	X	-	X	X	X	X	X	-	X
F. exasperata	X	X	X	-	-	-	-	-	-	X	-	-
F. racemosa	X	X	-	-	-	-	-	-	-	-	-	-

Plate 9. A. Jungle crows having their evening feeding bout on _F. benghalensis_.

B. A Small Green Barbet hangs down from a twig and pick up the fig of _F. benghalensis_.

PLATE 9

A

B

The Small Green Barbet (78.51%) and the Coppersmith Barbet (68.36%) were the commonest visitors. The Koel occurred in 61.79% of observations. These three species were residents of the area. The Common Green Pigeon (T. Phoenicoptera) had a higher frequency of occurrence than the Grey fronted Green Pigeon (T. pompadora; Table 12). The Blossomheaded Parakeet and Roseringed Parakeet had 22.39% and 9.85% attendance respectively in the present study.

The Jungle Crow with an attendance of 52.54% was the commonest opportunists visited F. benghalensis crown. It had significantly greater frequency of occurrence than the House Crow (19.40% ; x^2 = 15.27, P < 0.001). The Tree Pie and the Common Myna had more or less similar frequency of occurrence (Table 12). The Golden oriole, Redvented Bulbul and Tree Pie were present in 44, 37, 36 and 33 consuses respectively and had similar visitation pattern (P > 0.30). The Brahming Myna (S. pagodarum) and the large Indian Cuckoo Shrike were present in 24 and 23 censuses (< 10%) respectively.

Fifteen different species of birds were seen utilising the fig resource of F. exasperata. The foraging activities of avian frugivores at this fig have been monitored for 129 hours. A total of 349 bird activity censuses were carried out. The frugivore community included six specialists and nine opportunists.

TABLE 12. **Comparative frequencies of occurrence of important avian frugivores on various fruiting *Ficus* species in the Thenhipalam Site**

Data are percentages of occurrence. Data in parentheses are (1) total number of bird activity census; (2) number of occurrence of the bird species (Frequencies of occurrence of those species with less than 5% observations are not considered)

Sl. No.	Bird Taxon	*F. tsjahela* (216)[1]	*F. religiosa* (182)	*F. amplissima* (151)	*F. benghalensis* (335)	*F. exasperata* (349)	*F. racemosa* (133)
1.	*E. scolopacea*	41.20 (89)[2]	59.89 (109)	80.79 (122)	61.79 (207)	77.08 (269)	26.32 (35)
2.	*M. virdis*	83.79 (181)	73.62 (134)	84.10 (127)	78.51 (263)	51.86 (181)	24.81 (33)
3.	*M. haemacephala*	80.55 (174)	73.07 (133)	69.54 (105)	68.36 (263)	24.35 (181)	20.30 (33)
4.	*T. phoenicoptera*	25.46 (55)	52.74 (96)	28.47 (43)	50.15 (168)	20.34 (71)	10.53 (14)
5.	*T. pompadora*	25 (54)	14.29 (26)	--	7.46 (24)	10.00 (35)	6.02 (8)
6.	*T. bicincta*	6.08 (13)	6.04 (11)	--	--	--	--
7.	*P. cyanocephala*	10.64 (23)	34.06 (62)	10.60 (16)	22.39 (75)	--	--
8.	*P. krameri*	--	13.19 (24)	--	9.85 (33)	--	--
9.	*P. cafer*	10.18 (22)	30.76 (56)	9.27 (14)	10.75 (36)	5.15 (18)	--
10.	*P. jocosus*	--	28.57 (52)	8.60 (13)	--	--	--
11.	*C. macrorhynchos*	10.18 (22)	28.02 (51)	39.07 (59)	52.54 (176)	13.47 (47)	23.30 (31)
12.	*C. splendens*	--	24.18 (44)	8.60 (13)	19.40 (65)	6.02 (21)	15.79 (21)
13.	*D. vagabunda*	--	34.07 (62)	10.60 (16)	28.36 (95)	5.44 (19)	--
14.	*A. tristis*	--	35.71 (65)	23.18 (35)	25.97 (81)	9.17 (32)	7.52 (10)
15.	*S. malabaricus*	--	8.24 (15)	7.28 (11)	9.85 (33)	--	--
16.	*S. pagodarum*	--	7.69 (14)	--	7.46 (24)	--	--
17.	*O. oriolus*	30.56 (66)	35.71 (65)	36.42 (55)	13.13 (44)	11.74 (41)	13.53 (18)
18.	*O. xanthornus*	15.27 (33)	17.58 (32)	5.96 (9)	--	--	--
19.	*D. erythrorhynchos*	20.37 (44)	17.23 (31)	12.58 (19)	11.04 (37)	--	--
20.	*C. novaehollandiae*	--	--	--	6.87 (23)	--	--
21.	*Z. citrina*	7.87 (17)	14.28 (26)	5.30 (8)	--	--	--
22.	*T. striatus*	--	7.69 (14)	--	--	--	--
23.	*T. affinis*	--	9.34 (17)	--	--	--	--

At this fig species the relative frequencies of occurrence of eleven species of birds were determined (Table 12). The Koel was the most important visitor with an attendance of 77.08%. It had significantly greater frequency of occurrence than burbets and fruit pigeon (x^2 = 48.38, P < 0.0001).

The Small Green Barbet with an attendance of 51.86% were also present in significantly greater number of observations than the Coppersmith Barbet and the Common Green Pigeon (x^2 = 18.88, P < 0.0001). The Coppersmith Barbet and the Common Green Pigeon were present in 24.35% and 20.34% censuses respectively. The Greyfronted Green Pigeon had only 10% attendance. The specialist Redvented Bulbul also had much lower frequency of occurrence (< 10%).

The opportunists were less attracted to this fig crop. The Jungle Crow and the Golden Oriole with frequencies of occurrence 13.47% and 11.47% respectively were the commoner visitors of this category. The common Myna, House Crow, and Tree Pie, were present at F. exasperata in less than 10% of observations (Table 12).

The avian assemblages and their activities were recorded during 77 hours of observations at Six Ficus racemosa trees present in the campus. A total of 133 bird activity censuses were taken. Despite their commonness and large number of crops borne per tree per year, the avian frugivore dependence were rather poor at these Ficus

TABLE 11. **Avian frugivores attending figs in the Vythiri site**

Codes for bird species are as given in table 6.

	Ficus spp.	TR	DB	BP	LV	TG	MV	MR	GO	GR	SB	CA	IP	PJ	HM	HI	ZC
1.	F. tsjahela	X	-	-	-	-	X	X	X	X	X	X	X	X	X	X	-
2.	F. microcarpa	X	-	-	-	-	X	X	-	X	X	-	X	X	X	X	-
3.	F. amplissima	X	X	X	X	X	X	X	X	X		-	X	X	X	X	X
4.	F. exasperata	X	X	X	X	X	X	X	X	X	-	-	X	X	X	X	-
5.	F. nervosa	X	X	X	-	X	X	X	-	X	-	-	X	X	X	-	-
6.	F. beddomei	X	X	X	X	X	X	X	X	X	-	-	-	-	X	-	-
7.	F. virens	X	-	X	-	-	X	X	-	X	-	-	-	X	X	X	-

contd.....

Table 11 contd...

	Ficus spp.	MC	MS	LW	TM	PX	DE	DC	ZP	CE
1.	*F. tsjahela*	-	X	X	-	-	X	X	X	-
2.	*F. microcarpa*	-	-	-	X	X	X	X	X	-
3.	*F. amplissima*	X	X	-	X	-	X	X	X	X
4.	*F. exasperata*	-	-	-	X	-	X	X	X	-
5.	*F. nervosa*	-	-	-	X	-	-	-	-	-
6.	*F. beddomei*	-	-	-	X	-	-	-	-	X
7.	*F. virens*	-	-	-	-	-	-	-	X	-

species in this study area. The guild of frugivores included six specialists such as the fruit pigeons *T. phoenicoptera* *T. pompadora*, *T. bicincta*, barbets *M. virdis*, *M. hacomacephala* and the Koel *E. scolopacea*. The opportunistic species were crows, *C. macrorhynchos*, *C. splendens*, oriole *O. oriolus*, and the Myna *A. tristis*.

E. scolopacea, *M. virdis*, *M. haemacephala* and *C. macrorhynchos* were the commoner visitors at this fig crop. They had similar frequencies of occurrence (Table 12; P > 30, chi-square test). The three species of fruit pigeons, namely *T. phoenicoptera*, *T. pompadora* and *T. bicincta* were observed in only 5% to 10% of censuses only. They ate even the immature figs and were thus seed predators. Crows *C. macrorhynchos* and *C. splendens* were the commonly observed opportunists (23.30% and 15.79% respectively). The Golden Oriole and the Common Myna had 13.53% and 7.52% of attendance respectively.

Sixteen species of birds visited the fruiting crown of *F. amplissima* (Table 10). The avian foraging behaviour was observed at 3 trees of this fig species for a total of 94 hours. 151 bird activity censuses were carried out. The specialists eating this fig crop were the Koel, Small Green Barbet, Coppersmith Barbet, Common Green Pigeon, Blossomheaded Parakeet, Roseringed Parakeet, Redvented Bulbul and Redwhiskered Bulbul. The opportunists consisted of the Jungle Crow, House Crow, Common Myna, Tree Pie, Golden Oriole, Blackheaded Oriole, Grey headed Myna and Tickell's Flowerpecker.

The Small Green Barbet and the Koel which occurred in over 80% of censuses were the most frequented species (Table 12). Coppersmith Barbets (69.54%) were slightly less frequent than Small Green Barbets and Koels. The common Green Pigeon was present in 28.47% of censuses while Blossom headed Parakeets had very low attendance (10.60%). In the generalist category, the Jungle Crow and the Golden Oriole were observed more frequently (39.07% ; 36.42% respectively). than others. The House Crow was significantly less frequent than the Jungle Crow ($x^2 = 4.47$ $P < 0.05$). The common Myna was found in 35 censuses (23.18%) while the Tickell's Flowerpecker was present in 16 censuses. The other opportunists were present in less than 10% censuses only.

Observations on avian frugivore activity were conducted on Six trees of *F. religiosa* for a total of 126 hours. Twentysix species of birds comprising ten specialist and fifteen opportunists ate these figs (Table 10). The specialists included three species of Green Pigeons such as the Common, the Greyfronted and the Orangebreasted. A small flock of ten of the third species was seen in the area for 2 to 3 weeks during January-February 1991. It was a transient migrant.

Of the opportunistic visitors, the Goldfronted Chloropsis (*Chloropsis aurifrons*) and Magpie robin (*Copsychus saularis*) was observed consuming this fig at least once. Table 12 describes the frequency of occurrence of twenty two species of birds. The Small Green Barbet and the coppersmith Barbet with 73.62% and 73.07% attendances respectively were the commonest visitors. The Koel and the Common Green Pigeon were present in 59.89% and 52.74% of census respectively. The Greyfronted Green Pigeon and Orangebreasted Green Pigeon had much lower frequencies of occurrence than the common Green Pigeon (Table 12). The Blossomheaded and Roseringed Parakeets were also occurred in only a very few censuses where as the Redvented and Redwhiskered Bulbuls occurred in 56 and 52 censuses respectively.

The Common Myna, Golden Oriole and Tree Pie had equal and similar attandances (Table 12) and were the Common opportunists visiting Ficus religiosa fruiting crown. The Jungle Crow and the House Crow have almost similar attandances (51 and 44 census repectively; x^2 = 0.52, P > 0.30). The Blackheaded Oriole, and the Tikell's Flowerpecker were present in more or less similar number of observations (Table 12). While the Greyheaded Myna, Brahminy Myna, Jungle Babbler and Whiteheaded Babbler had much lower attendances (Table 12).

At Ficus tsjahela fruiting crown, the avian frugivore activities were monitored for 73 hours. The observations were carried out on the two trees present in the area. Two hundred and sixteen bird activity censuses were undertaken during the present study. Sixteen species of fruit-eating birds were seen eating those very small figs

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Plate-10. _F. benghalensis_ crown:-

a. Golden Oriole at search for a ripe fig.

b. A Greyheaded Myna at rest after a sumptuous meal.

Plate 10

a

b

(Table 10). This frugivore guild consisted of eight specialists and eight opportunists. The frequencies of occurrence of thirteen avian visitors were studied (Table 12). The Small Green Barbet and the Coppersmith Barbet were the commonest visitors (> 80%). They had significantly greater attendances than Koel and fruit pigeons (x^2 = 41.72 P < 0.001). The Koel was present in 89 observations (41.20%) while the two fruit pigeons, the Common Green Pigeon and the Greyfronted Green Pigeon had much lower and similar frequencies of occurrence (25.46% ; 25% respectively). The Common Green Pigeon (T. phoenicoptera) showed the least preference to these small figs ($\bar{X}$ 4.54 mm diameter). The Orangebreasted Green Pigeon (T. bicincta) was observed only for a short time in February 1991 (6% attendance). The Blossomheaded Parakeet and the Redvented Bulbul had similar and much fewer attendances at F. tsjahela (23 and 22 censuses respectively). The opportunist Jungle Crow had a similar attendace (Table 12).

Among the opportunists, the Golden Oriole had the highest frequency of occurrence (30.56%). Its congener the Blackheaded Oriole had significantly lower attendance at this fig (15.27% , x^2 = 5.10, P > 0.02). The Tickell's Flowerpecker with an attendance of 20.37% was the other prominent opportunists utilising this fig crop while the Whitethroated Ground Thrush had the lowest attendance of the thirteen bird species studied (Table 12).

Frequency of Visits

The relative member of visits per hour of observation by fourteen species of birds were estimated at *F. benghalensis* (Table 13). The Small Green Barbet and the Coppersmith Barbet had similar visitation rates (U = 64.5 P > 0.30 2-way Mann-Whitney U test). However, the Small Green Barbet with a mean 3.63 visits per hour was the most frequented species. It made significantly greater number of visits than the Koel and the Common Green pigeon (P < 0.002 Mann-Whitney U test). The Koel and the Green Pigeon made an average 2.35 and 2.33 visits per hour respectively. Both the Blossomheaded and Roseringed Parakeet had much lower frequencies of visit than other specialists ($\bar{X}$ 0.08 ± 0.05 ; $\bar{X}$ 0.09 ± 0.06 visits per hour respectively).

The opportunistic visitors were less frequent than the specialists (Table 13). The Jungle Crow, House Crow, Tree Pie, Golden Oriole and Common Myna had similar visitation rates (P > 0.30). The Blackheaded Oriole, the Grey-headed Myna and the Large Cuckoo Shrike had similar and very low rates of visitation (Table 13).

The frequency of visits of eleven species of birds at *F. exasperata* were estimated in the present study. The Koel which made

TABLE 13. **Group size, Visitation length, Visitation rate, Feeding rate and Fruit removal rate of important avian frugivores at *Ficus benghalensis* (Tenhipalam Site)**

Figures are means with standard deviation (Sample sizes in parentheses)

Sl. No.	Bird species	Group size (mean ± SD)	Visitation Length	Visitation Rate	Feeding rate	Fruit removal rate
1.	*E. scolopaeca*	3.90 ± 2.31 (50)	645.17 ± 425.59 (63)	2.35 ± 0.46(12)	0.30 ± 0.18 (35)	29.56
2.	*M. virdis*	7.44 ± 4.69 (50)	715.22 ± 515.76 (58)	3.63 ± 0.67 (13)	0.34 ± 0.21 (58)	109.46
3.	*M. haemacephala*	8.84 ± 5.60 (50)	708.80 ± 496.14 (57)	3.13 ± 0.92 (13)	0.17 ± 0.14 (47)	58.76
4.	*T. phoenicoptera*	12.70 ± 9.39 (50)	709.66 ± 503.15 (86)	2.33 ± 0.88 (11)	0.21 ± 0.15 (65)	80.04
5.	*P. cyanocephala*	3.10 ± 1.61 (29)	1099.18 ± 664.64 (34)	0.77 ± 0.64 (11)	0.08 ± 0.05 (28)	3.50
6.	*P. krameri*	2.88 ± 1.15 (16)	972.61 ± 654.14 (18)	0.57 ± 0.50 (11)	0.09 ± 0.06 (16)	2.39
7.	*C. macrorhynchos*	8.80 ± 10.23 (50)	482.28 ± 314.03 (53)	1.67 ± 0.99 (11)	0.19 ± 0.17 (60)	22.44
8.	*C. splendens*	7.37 ± 6.01 (38)	451.91 ± 313.61 (46)	1.08 ± 0.82 (10)	0.17 ± 0.15 (20)	10.19
9.	*O. oriolus*	3.24 ± 1.76 (50)	334 ± 206.00 (24)	1.84 ± 1.00 (8)	0.15 ± 0.12 (23)	4.98
10.	*O. xanthornus*	1.70 ± 0.88 (30)	303.08 ± 174.92 (24)	0.60 ± 0.24 (6)	0.10 ± 0.08 (19)	0.52
11.	*A. tristis*	4.94 ± 2.72 (50)	391.50 ± 239.02 (52)	1.83 ± 1.19 (10)	0.16 ± 0.11 (49)	9.44
12.	*D. vagabunda*	2.08 ± 1.10 (40)	366.35 ± 233.81 (51)	1.50 ± 1.08 (9)	0.18 ± 0.15 (47)	3.43
13.	*S. malabaricus*	15.48 ± 11.20 (29)	591.39 ± 365.74 (33)	1.61 ± 0.91 (9)	0.11 ± 0.11 (32)	27.02
14.	*C. novaehollandiae*	1.43 ± 0.51 (14)	328.60 ± 186.02 (19)	0.79 ± 0.55 (8)	0.11 ± 0.08 (19)	0.69

TABLE 14. **Group size, Visitation length, Visitation rate, Feeding rate and Fruit removal rate of important avian frugivores at *Ficus exasperata* at Tenhipalam site** (Figures are means with standard deviation)

Sl. No.	Bird species	Group size	Visitation length	Visitation rate	Feeding rate	Fruit removal rate
1.	*E. scolopacea*	3.84 ± 1.95 (56)	539.94 ± 499.87 (64)	2.31 ± 0.86 (16)	0.57 ± 0.42 (68)	45.50
2.	*M. virdis*	3.12 ± 1.88 (49)	367.82 ± 274.16 (56)	2.26 ± 1.07 (15)	0.51 ± 0.34 (46)	22.05
3.	*M. haemacephala*	2.62 ± 1.66 (48)	262.26 ± 155.86 (23)	1.03 ± 0.86 (14)	0.19 ± 0.13 (16)	2.24
4.	*T. phoenicoptera*	4.76 ± 3.90 (39)	445.9 ± 273.81 (49)	1.00 ± 0.88 (11)	0.43 ± 0.21 (44)	15.21
5.	*T. pompadora*	5.32 ± 3.54 (35)	651.61 ± 476.82 (33)	0.97 ± 1.13 (8)	0.41 ± 0.21 (33)	22.98
6.	*C. macrorhynchos*	2.11 ± 2.20 (44)	252.58 ± 208.81 (24)	0.59 ± 0.80 (10)	0.22 ± 0.22 (21)	1.15
7.	*C. splendens*	1.63 ± 1.01 (19)	228.95 ± 199.87 (20)	0.32 ± 0.52 (11)	0.21 ± 0.19 (25)	0.42
8.	*O. oriolus*	2.18 ± 1.33 (34)	256.60 ± 133.52 (25)	1.56 ± 1.49 (10)	0.20 ± 0.17 (27)	2.91
9.	*O. xanthornus*	1.71 ± 0.95 (7)	259.94 ± 216.87 (18)	0.31 ± 0.29 (8)	0.13 ± 0.13 (19)	0.29
10.	*A. tristis*	2.17 ± 1.24 (27)	198.87 ± 137.09 (30)	0.46 ± 0.52 (10)	0.23 ± 0.21 (25)	0.76
11.	*D. vagabunda*	1.50 ± 0.65 (14)	146.37 ± 85.83 (19)	0.37 ± 0.64 (9)	0.26 ± 0.18 (28)	0.36

TABLE 15. **Group size, Visitation length, Visitation rate, Feeding rate, and Fruit Removal rate of important avian visitors at *Ficus racemosa* (Tenhipalam Site)** (Figures are means with standard deviation. Sample sizes in parentheses)

Sl. No.	Bird species	Group size	Visitation length	Visitation rate	Feeding rate	Fruit removal rate
1.	*E. scolopacea*	1.78 ± 1.44 (33)	467.42 ± 345.72 (24)	1.06 ± 0.74 (11)	0.37 ± 0.33 (21)	5.44
2.	*M. virdis*	2.04 ± 1.49 (25)	366.33 ± 152.65 (18)	0.88 ± 0.57 (15)	0.35 ± 0.43 (20)	3.84
3.	*M. haemacephala*	1.80 ± 0.77 (20)	320.71 ± 255.50 (21)	1.02 ± 0.98 (11)	0.12 ± 0.12 (21)	1.18
4.	*T. phoenicoptera*	8.71 ± 4.11 (8)	531.57 ± 300.55 (21)	0.44 ± 0.31 (8)	0.16 ± 0.13 (20)	5.43
5.	*T. pompadora*	3.25 ± 2.38 (8)	553.72 ± 345.26 (25)	0.40 ± 0.40 (6)	0.17 ± 0.16 (19)	2.04
6.	*C. macrorhynchos*	4.50 ± 3.70 (17)	351.86 ± 154.02 (28)	0.60 ± 0.60 (8)	0.18 ± 0.22 (25)	2.85
7.	*C. splendens*	3.50 ± 3.21 (14)	418.22 ± 290.58 (25)	0.78 ± 0.42 (8)	0.14 ± 0.14 (21)	2.66

TABLE 16. **Group size, Visitation length, Visitation rate, Feeding rate and Fruit removal rate of important bird species at *Ficus amplissima* (Tenhipalam Site)**

Sl. No.	Bird species	Group size	Visitation length	Visitation rate	Feeding rate	Fruit removal rate
1.	*E. scolopaeca*	4.27 ± 2.89 (49)	534.81 ± 363.86 (72)	2.73 ± 1.21 (16)	1.31 ± 1.26 (61)	136.12
2.	*M. virdis*	4.73 ± 2.97 (56)	592.72 ± 364.83 (67)	3.61 ± 1.54 (17)	1.14 ± 0.74 (70)	192.30
3.	*M. haemacephala*	7.20 ± 5.40 (38)	564.56 ± 471.82 (46)	2.89 ± 0.89 (13)	0.90 ± 0.69 (36)	176.21
4.	*T. phoenicoptera*	11.26 ± 7.40 (35)	599.46 ± 418.58 (58)	2.24 ± 0.52 (8)	1.25 ± 0.79 (56)	315.00
5.	*C. macrorhynchos*	5.06 ± 5.66 (47)	385.38 ± 236.56 (50)	1.23 ± 1.03 (12)	0.53 ± 0.48 (59)	21.19
6.	*C. splendens*	4.75 ± 2.70 (12)	364.80 ± 250.62 (30)	0.61 ± 0.41 (9)	0.40 ± 0.34 (39)	7.05
7.	*O. oriolus*	2.46 ± 1.39 (43)	445.69 ± 260.07 (32)	3.09 ± 1.42 (9)	0.66 ± 0.57 (45)	37.27
8.	*O. xanthornus*	2.00 ± 0.85 (15)	215.35 ± 97.22 (20)	0.41 ± 0.36 (9)	0.50 ± 0.39 (20)	1.47
9.	*A. tristis*	7.45 ± 3.17 (29)	468.07 ± 291.34 (45)	2.28 ± 2.47 (9)	0.57 ± 0.45 (40)	75.53
10.	*D. vagabunda*	1.67 ± 1.11 (15)	257.69 ± 127.68 (35)	1.02 ± 0.84 (9)	0.43 ± 0.34 (40)	3.16

TABLE 17. **Group size, Visitation length, Visitation rate, Feeding rate, Fruit removal rate etc. of 'important' avian visitors at *Ficus religiosa* (Tenhipalam site)** (Figures are means with standard deviation. Sample size in parentheses)

Sl. No.	Bird species	Group size	Visitation length	Visitation rate	Feeding rate	Fruit removal rate
1.	*E. scolopacea*	2.91 ± 1.67 (49)	542.22 ± 401.14 (49)	2.35 ± 0.79 (13)	1.89 ± 1.43 (51)	116.80
2.	*M.virdis*	6.48 ± 4.55 (40)	587.87 ± 413.79 (70)	3.19 ± 1.13 (11)	1.93 ± 1.36 (77)	390.89
3.	*M. haemacephala*	7.02 ± 4.80 (48)	531.42 ± 472.12 (53)	3.20 ± 0.82 (13)	1.61 ± 1.38 (52)	320.33
4.	*T. phoenicoptera*	9.56 ± 6.99 (48)	572.20 ± 483.62 (46)	2.43 ± 0.94 (9)	1.81 ± 1.62 (44)	401.00
5.	*P. cyanocephala*	3.14 ± 1.10 (14)	1233.18 ± 1041.07 (17)	0.62 ± 0.31 (7)	0.21 ± 0.14 (18)	8.40
6.	*C. macrorhynchos*	5.90 ± 3.97 (29)	329.25 ± 270.81 (32)	1.23 ± 0.95 (11)	0.57 ± 0.75 (29)	22.70
7.	*C. splendens*	6.50 ± 4.62 (38)	340.73 ± 210.23 (48)	1.13 ± 0.99 (9)	0.56 ± 0.65 (40)	23.36
8.	*O.oriolus*	3.84 ± 2.13 (48)	373.40 ± 274.88 (52)	3.11 ± 2.11 (13)	1.52 ± 1.19 (36)	120.60
9.	*O. xanthornus*	1.59 ± 0.72 (30)	194.39 ± 144.50 (28)	0.74 ± 0.39 (9)	1.17 ± 1.15 (24)	4.46
10.	*A. tristis*	5.66 ± 2.79 (50)	246.65 ± 164.52 (43)	2.29 ± 1.25 (12)	1.05 ± 0.89 (39)	55.96
11.	*D. vagabunda*	2.32 ± 1.08 (46)	166.16 ± 125.65 (37)	1.42 ± 1.08 (10)	0.98 ± 1.20 (36)	8.94
12.	*P. cafer*	3.25 ± 1.02 (20)	149.86 ± 86.62 (43)	2.62 ± 0.93 (12)	0.79 ± 0.77 (42)	16.80
13.	*P. jocosus*	2.57 ± 0.94 (14)	141.05 ± 71.87 (39)	2.58 ± 0.92 (7)	0.74 ± 0.71 (34)	11.53

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TABLE 18. **Group size, Visitation length, Visitation rate, Feeding rate and Fruit removal rate of important avian at *Ficus tsjahela* (Tenhipalam Site)**

Sl. No.	Bird species	Group size	Visitation length	Visitation rate	Feeding rate	Fruit removal rate
1.	*E. scolopaeca*	3.56 ± 2.82 (50)	592.94 ± 418.86 (31)	1.68 ± 1.19 (15)	1.81 ± 1.28 (37)	106.98
2.	*M. virdis*	6.56 ± 4.25 (46)	630.17 ± 460.89 (60)	3.60 ± 0.81 (20)	2.60 ± 1.57 (52)	644.89
3.	*M. haemacephala*	8.24 ± 5.25 (50)	581.67 ± 459.30 (21)	3.15 ± 0.75 (19)	2.23 ± 1.24 (20)	588.41
4.	*T. phoenicoptera*	7.24 ± 5.10 (50)	667.87 ± 458.22 (23)	1.18 ± 0.58 (12)	2.70 ± 1.44 (22)	256.76
5.	*T. pompadora*	9.86 ± 7.69 (49)	575.96 ± 349.35 (21)	1.96 ± 0.35 (10)	2.86 ± 1.22 (43)	530.57
6.	*O. oriolus*	2.91 ± 1.68 (34)	362.86 ± 292.64 (43)	3.07 ± 1.58 (17)	1.76 ± 1.22 (42)	95.09
7.	*O. xanthornus*	1.33 ± 0.71 (21)	298 ± 157.48 (18)	0.82 ± 0.50 (11)	1.08 ± 0.69 (17)	5.85
8.	*C. macrorhynchos*	2.52 ± 2.25 (21)	220.74 ± 144.44 (34)	0.48 ± 0.38 (12)	0.41 ± 0.57 (36)	1.82
9.	*D. erythrorhyncos*	1.67 ± 0.72 (27)	288.75 ± 224.23 (20)	2 ± 0.77 (10)	0.93 ± 0.54 (20)	14.95

an average 2.3 visits per hour had the highest visitation rate (Table 14). The Samll Green Barbet also had a higher rate of visitation ($\bar{x}$ 2.26 $\pm$ 1.07 visit/hr.). These two species differed significantly from other avian frugivores ($p \geq 0.05$, 2 tailed M-W U test) except the Golden Oriole ($\bar{x}$ 1.56 $\pm$ 1.49 visits/hr.). The common (T. phoenicoptera) and Greyfronted Green Pigeons (T. pompadora) and the Coppersmith Barbet had similar rates of visitation ($P > 0.30$). The Tree Pie, Common Myna, Blackheaded Oriole, and House Crow had similar and much lower frequency of visits ($P > 0.50$). The Jungle Crow ($\bar{x}$ 0.59 $\pm$ 0.80 visits/hr.) had slightly greater frequency of visits than the House Crow ($\bar{x}$ 0.32 $\pm$ 0.52 visits/hr).

Table 15 describes the frequency of visits of seven avian frugivores visiting F. racemosa. The Koel, the Small Green Barbet and the Coppersmith Barbet had smimilar and moderate visitation rates. (Table 15, $P > 0.50$). These three resident and specialised frugivores were significantly more frequently visiting this fig crown than the fruit pigeons ($P < 0.05$ M-W U test). The common and Greyfronted Green Pigeons performed similar number of feeding visits in an hour of observation ($\bar{x}$ 0.44 $\pm$ 0.31 ; $\bar{x}$ 0.40 $\pm$ 0.40 visits per hour respectively). The visitation frequency of the Orangebreasted Green Pigeon was not considered as it had only a negligible number of feeding attempts at this fig during its two weeks presence in the Study area. The House Crow ($\bar{x}$ 0.78 $\pm$ 0.42 visits/hr.) had slightly greater visitation rate than the Jungle Crow ($\bar{x}$ 60 $\pm$ 0.60 visit/hr.).

55.3

Plate 11. F. ~~benghalensis~~ tsjahela. Crown

Small Green Barbet is hiding itself behind foliage at hot mid-day time.

Plate 11

The mean visitation rates of ten species of birds utilising F. amplissima fig crop are given in table 16. The Small Green Barbet with a mean 3.61 visits per hour was the most frequent visitor. The opportunist Golden Oriole which had an average 3.09 visits per hour was a commoner visitor than many specialists. The Coppersmith Barbet and the Koel had similar visitation rates ($\bar{x}$ 2.73 ± 1.21 ; $\bar{x}$ 2.89 ± 0.89 visits per hour respectively. U = 97.5 , P > 0.30 M-W U test). The common Green Pigeon undertook 2 to 3 visits in an hour of observation ($\bar{x}$ 2.24 ± 0.52 visits/hr).

The Golden Oriole was the most common opportunists visiting this fig crown. It has significantly high rates of visitation than other opportunistic fig-eaters. ($P < 0.05$, Table 16). The common Myna with an average 2.24 visits per hour was the other important opportunists at F. amplissima. The Jungle Crow and the Tree Pie visited slightly more frequently than the House Crow (Table 16). The Blackheaded Oriole was very infrequently observed ($\bar{x}$ 0.41 ± 0.36 visits/hr). It differed significantly from the Golden Oriole in the frequency of visit.

The average visitation rates of nineteen bird species attending Ficus religiosa were estimated (Table 17). The greatest number of visits per hour were undertaken by the Small Green Barbet and the coppersmith Barbet ($\bar{x}$ 3.19 ± 1.13; $\bar{x}$ 3.17 ± 0.82 visits/hour respectively). The opportunist Golden Oriole had a similar and higher visitation rate as the barbets (Table P > 0.30). The Common Green Pigeon, Koel made 2 to 4 visits in an hour and had similar frequency of visits (P > 0.30, Mann-Whitney U test). The Blossomheaded Parakeet visited an average 0.67 times/hour while the Roseringed Parakeet has still lower visitation rate. The Red-vented Bulbul and the Redwhiskered Bulbul had similar visitation rates ($\bar{x}$ 2.62 $\pm$ 0.93 ; $\bar{x}$ 2.58 $\pm$ 0.98 visits/hr respectively).

The Golden Oriole was the most frequent opportunists ($\bar{x}$ 3.11 $\pm$ 2.11 visit/hr,) followed by the Common Myna ($\bar{x}$ 2.29 $\pm$ 1.25 visits/hr.). The Jungle Crow, House Crow, Tree Pie, Greyheaded Myna and Tickell's Flowerpecker visited F. religiosa fruiting crown only less frequently (Table 17). The Blackheaded Oriole, Large Cuckoo Shrike and White-throated Ground Thrush each had an average less than one visit per hour (Table 17).

In F. tsjahela the relative mean frequencies of visit of nine different avian frugivores were recorded (Table 18). The Small Green Barbet made 5 to 6 visits in an hour of observation ($\bar{x}$ 3.6 $\pm$ 0.81 visits/hr). The Coppersmith Barbet and the Golden Oriole had similar and higher frequencies of visits ($\bar{x}$ 3.15 $\pm$ 0.75; $\bar{x}$ 3.07 $\pm$ 1.98 visits per hour respectively, P > 0.30). These three fruit-eaters made significantly greater number of visits per hour than all the foragers (P < 0.001 2-tailed Mann-Whitney U test). The Koel and the Greyfronted Green Pigeon foraged average 1.68 and 1.96 times respectively. The Common Green Pigeon ($\bar{x}$ 1.18 $\pm$ 0.58 visits/hr.) had significantly lower frequency of visits than the Greyfronted Green Pigeon. (U = 15, P = 0.002, Mann-Whitney U test).

The Golden Oriole was the most frequently visited opportunists followed by the Tickell's Flowerpecker ($\bar{x}$ 2.00 $\pm$ 0.77 visits/hour). The Blackheaded Oriole and the Jungle Crow were rather infrequent visitors ($\bar{x}$ 0.82 $\pm$ 0.50; $\bar{x}$ 0.48 $\pm$ 0.38 visits per hour respectively).

Feeding Bout

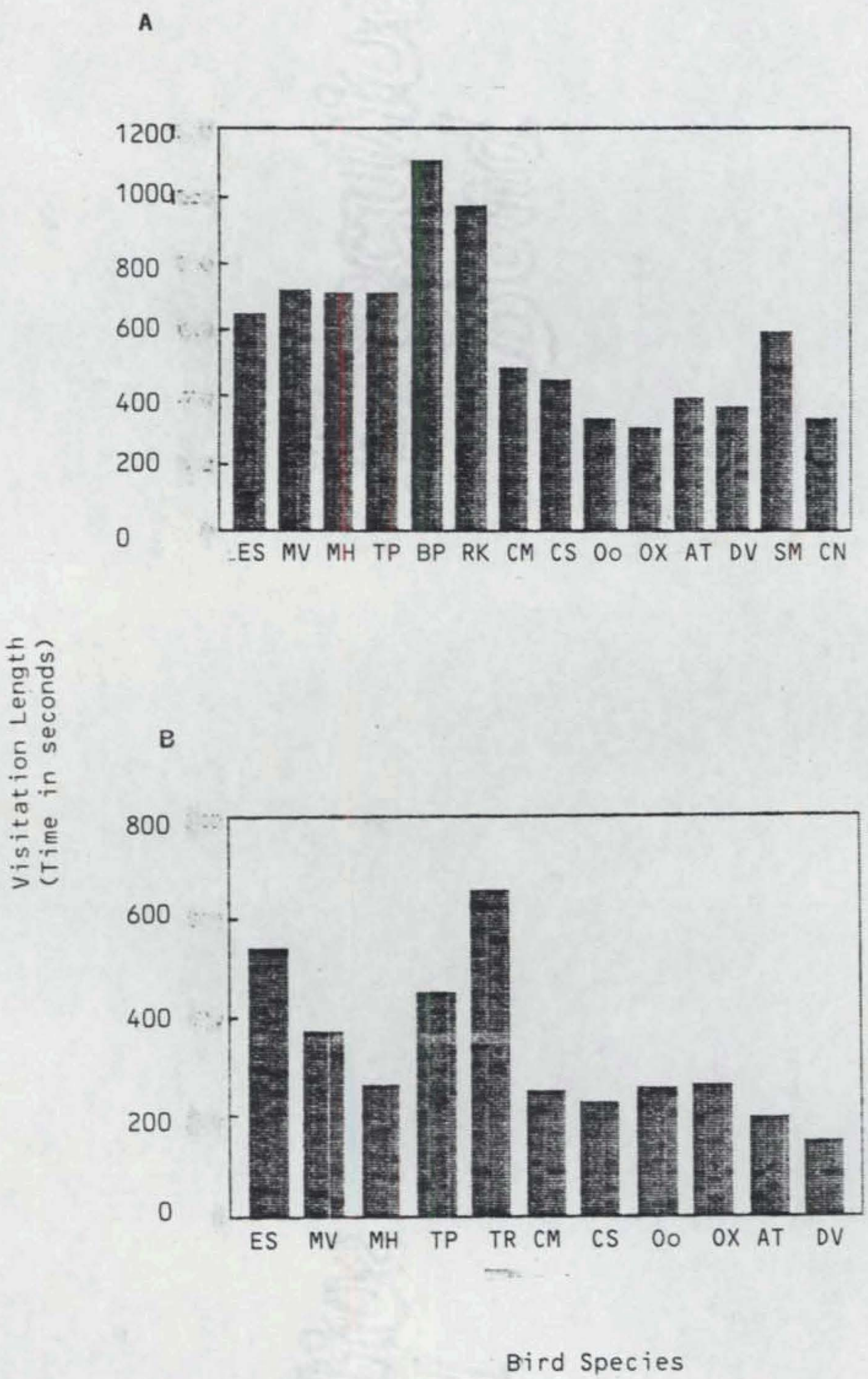
The length of feeding bout ie; time spent in each visit and the rate of successful bouts for each bird species were also considered as reliable measures of dependence of frugivores on a particular *Ficus* species and their relative efficiency in exploiting the resource.

Table 13 describes the relative visitation lengths of fourteen important frugivores studied in the present investigation at *F. benghalensis*. The Blossomheaded and Roseringed Parakeets spent the maximum time per visits (Fig. 4). They spent upto 40 or 45 minutes during a feeding visit. The common Green Pigeon, Koel, Small Green Barbet and Coppersmith Barbet had foraging visits as long as thirty

5

Fig. 4. Mean visitation lengths of important bird species at (a) *F. benghalensis*; (b) *F. exasperata* (Tenhipalam Site). Codes for birds used as given in table.

54.



A
1200
1000
800
600
400
200
0
ES MV MH TP BP RK CM CS Oo OX AT DV SM CN
Visitation Length
(Time in seconds)
B
800
600
400
200
0
ES MV MH TP TR CM CS Oo OX AT DV
Bird Species

or fourty minutes. The Grey-headed Myna with a mean visitation length of 591.39 seconds had the greatest feeding bouts among the opportunists. The Jungle crow and House Crow foraged for similar lengths of time per visit ($\bar{x}$ 482.28 $\pm$ 314.03 Sec; $\bar{x}$ 451. 91 $\pm$ 313.61 sec. respectively). Insectivores such as Common Myna, Tree Pie, Golden Oriole, Blackheaded Oriole and Large Cuckoo Shrike had relatively shorter and similar visitation patterns on *F. benghalensis* (Table 13). There was significant difference in bout length between specilists and opportunists. (U = 0, P = 0.001, M-W U test).

Koels and barbets were the most successful species at this *Ficus* species (Table 19). The Common Green Pigeon and the Greyfronted Green Pigeon had 92.15% and 85.71% successful visits respectively. The Parakeets were also highly successful at this fig crop. (Fig. 7).

The opportunists were less successful than the specialists (Fig. 7). The Jungle Crow and common Myna each with 80% success rate were the most efficient opportunists observed in the present study. The Golden Oriole and the Tree Pie had 75% and 76% successful bouts respectively. The House Crow was less successful than the Jungle Crow (Table 19). The Large Indian Cuckoo Shrike, Grey headed Myna and Blackheaded Oriole also had much lower and similar rates of success (Fig. 7).

The mean length of feeding bouts of eleven bird species at *F.*

59.B

Plate 12. _F. benghalensis_ Crown

a. Redvented Bulbul in search for ripe fig.

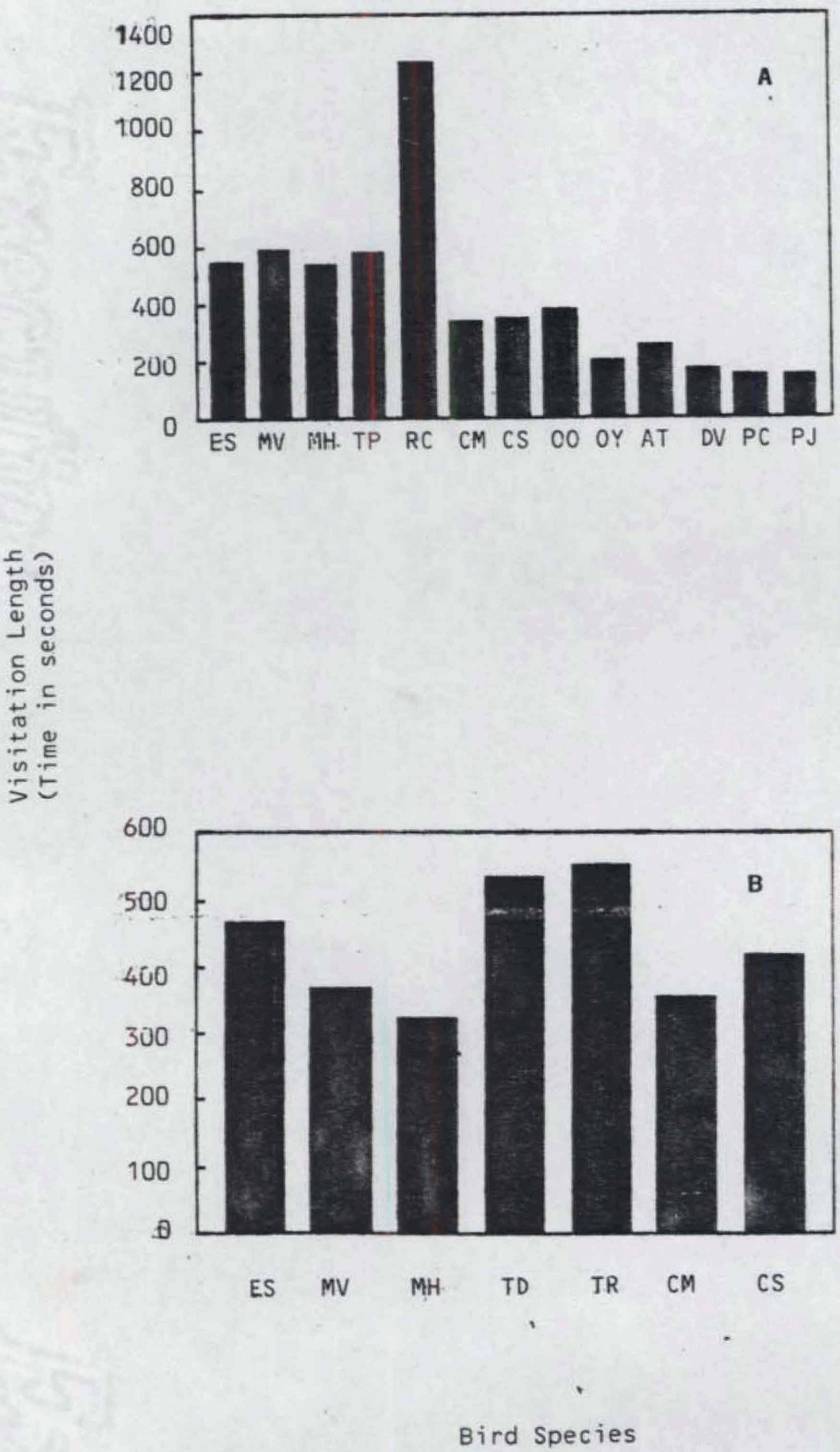
b. At feeding activity is a Common Myna in 'hanging down' position.

PLATE 1

a

b

Fig. 5. Mean visitation lengths of important bird species at (a) _F. religiosa_ (b) _F. racemosa_ (Bird codes as used in table 5).

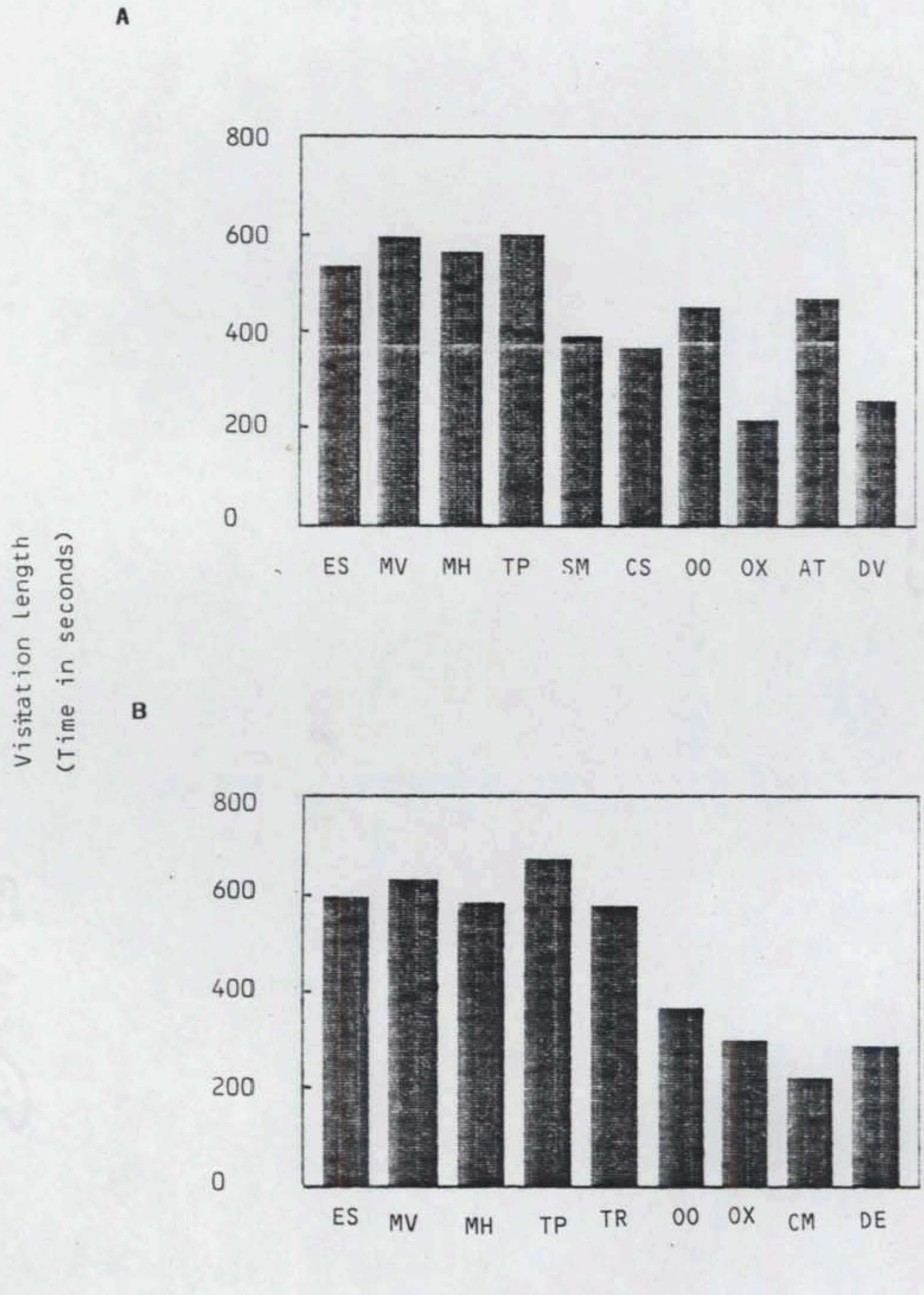

A
B
1400
1200
1000
800
600
400
200
0
ES MV MH TP RC CM CS OO OY AT DV PC PJ
600
500
400
300
200
100
0
ES MV MH TD TR CM CS
Visitation Length
(Time in seconds)
Bird Species

exasperata were recorded in the present study (Table 14 & Fig. 4). The two fruit pigeons, foraged for thirty to thirtyfive minutes in a visit while the Koel spent nearly twenty to twentyfive minutes per visit. These three specialists had significantly greater visitation lengths than other fig consumers at *F. exasperata* fruiting crown ($P > 0.002$, Mann-Whitney U test). The Small Green Barbet had a mean feeding bout length of 367.82 seconds while its congener, the Coppersmith barbet spent a slightly shorter time per visit ($\bar{x}$ 262.26 sec. $\pm$ 155.86 SD). The Jungle Crow, House Crow, Golden Oriole and Blackheaded Oriole foraged for similar lengths of time per visit (Table 14). The common Myna and the Tree Pie made much shorter feeding visits of four to five minutes duration only.

The specialists were significantly more successful and had higher success rates than the opportunists (Table 19; $x^2 = 32.6$, $P < 0.001$). The Koel, Small Green Barbet and Green Pigeons had over 90% successful feeding visits (Fig. 8). The Coppersmith Barbet achieved 81.08% success rate. The generalists like Jungle Crow, Hourse Crow, Common Myna, Golden Oriole and Blackheaded Oriole were successful in 60 to 70 % of their feeding bouts.

Foraging activities of seven species of birds were studied on the fruiting crown of *F. racemosa*. The Common and Grey fronted Green Pigeons foraged for fifteen to twenty minutes and they spent

Fig. 6. Mean visitation lengths of important bird species at (a) _F. amplissima_ (b) _F. tsjahela_ (Tenhipalam site) (Bird codes as used in table)


A
800
600
400
200
0
ES MV MH TP SM CS OO OX AT DV
Visitation length
(Time in seconds)
B
800
600
400
200
0
ES MV MH TP TR OO OX CM DE
BIRD SPECIES

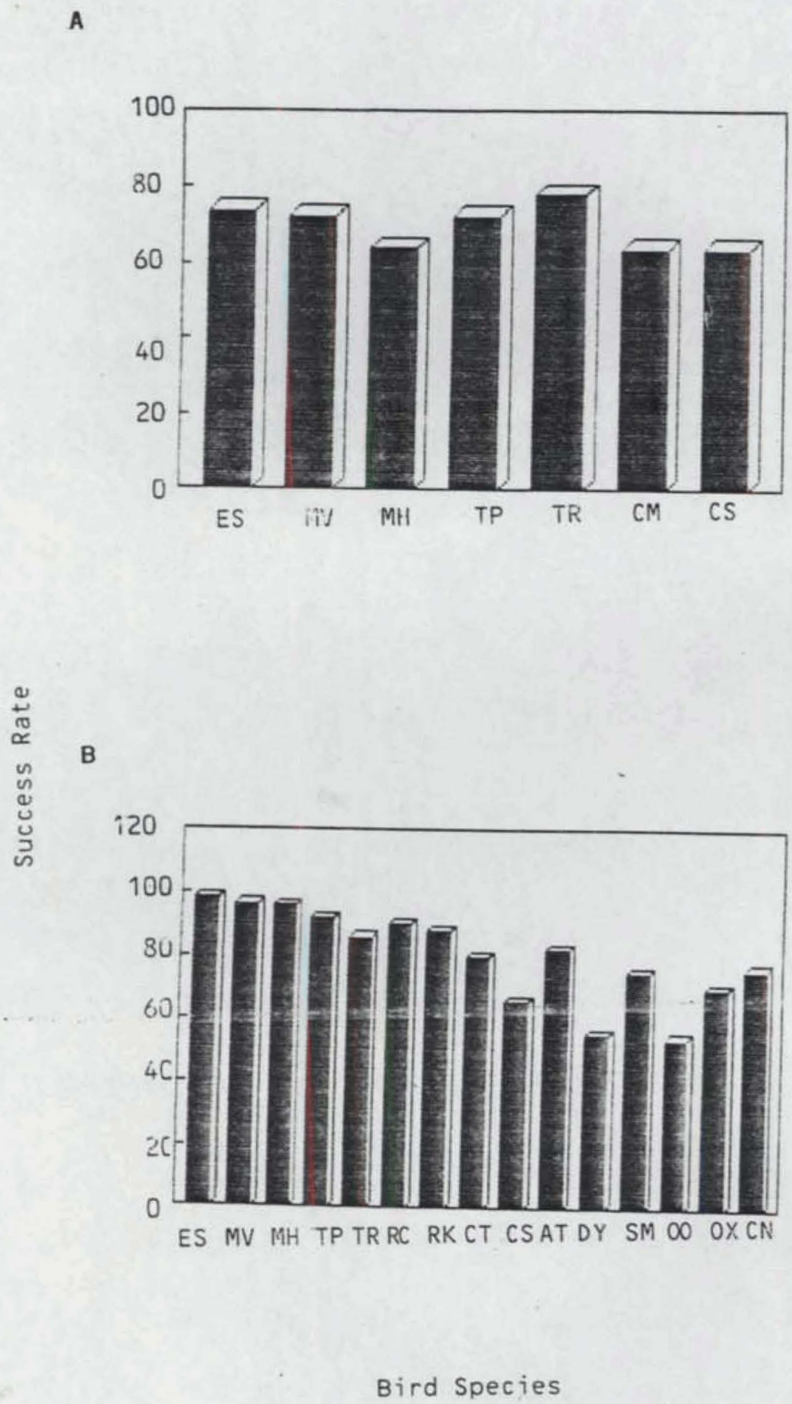
considerably longer time per bout than other frugivores. The Koel foraged for average eight minutes while barbets and crows had slightly shorter and similar feeding bouts (Table 15 and Fig. 5).

The Koel, Green Pigeon and Small Green Barbet were the most successful consumer having over 70% success rates at this fig species (Fig. 7). The Coppersmith Barbet and Crows had nearly 63% success rate each.

Table 16 and table 19 describe the relative visitation lengths and success rates of ten important avian visitors at F. amplissima. The Common Green Pigeon, Small Green Barbet, Coppersmith Barbet and Koel had more or less similar visitation lengths lasting ten to twenty minutes ($P > 0.30$). All these specialists had significantly longer feeding bouts than the opportunists ($P \geq 0.008$, 2-tailed Mann-Whitney U test). The Common Myna and Golden Oriole foraged for average 468.07 seconds and 445.69 seconds respectively. The latter spent much longer time per visit than the congener, Blackheaded Oriole ($\bar{x}$ 215.35 sec $\pm$ 97.22 SD). The two species of crows had similar and slightly shorter feeding bouts ($P > 0.30$). The Tree Pie foraged for six to seven minutes.

At F. religiosa the differential visitation lengths (Table 17 & Fig. 5) and success rates (Table 17, Fig. 9) of thirteen bird species were recorded. The Blossomheaded parakeet which foraged for about an

Fig. 7. Percent successful bouts of different frugivores on (a) *F. racemosa* (b) *F. benghallensis*


A
100
80
60
40
20
0
ES
MV
MH
TP
TR
CM
CS
Success Rate
B
120
100
80
60
40
20
0
ES MV MH TP TR RC RK CT CS AT DY SM OO OX CN
Bird Species

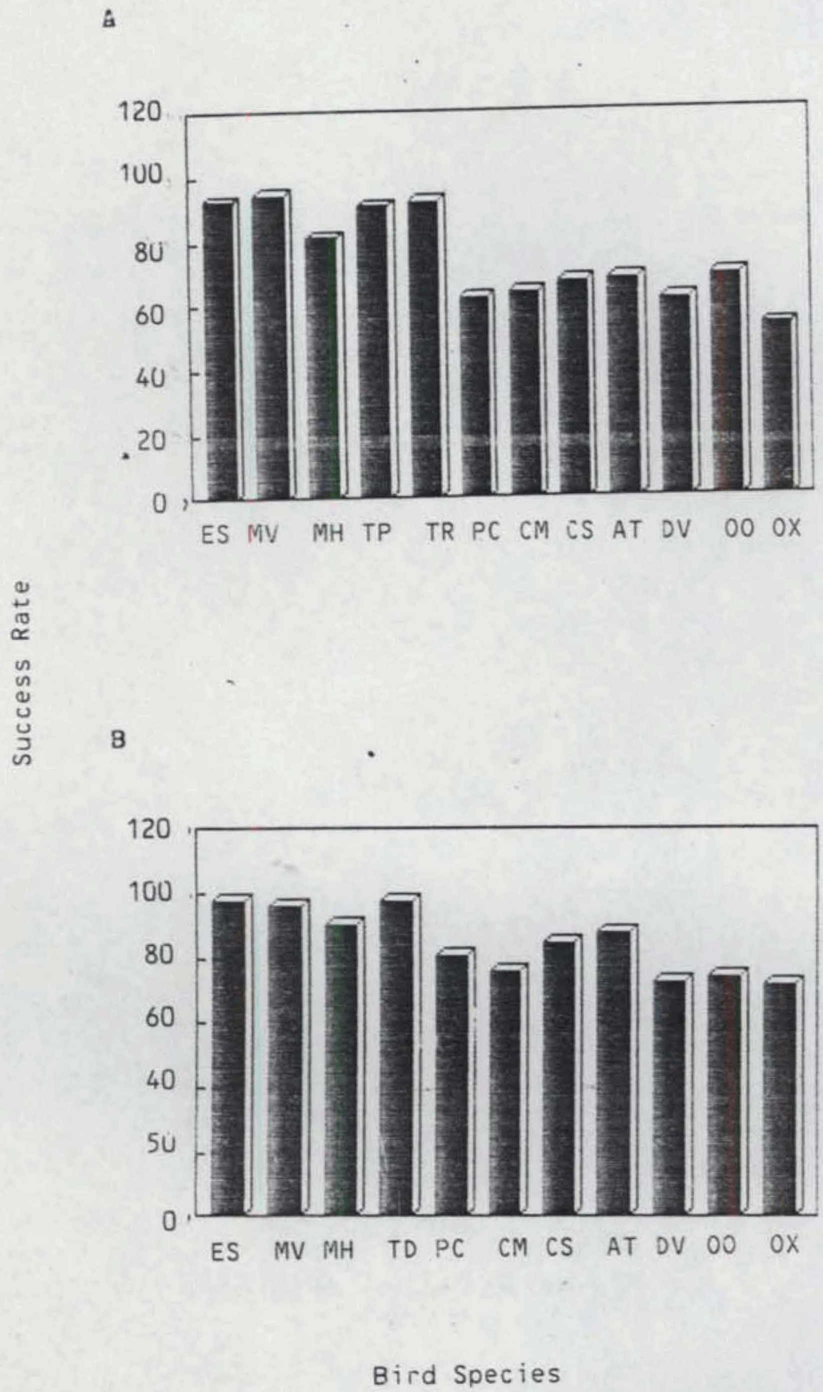
hour per visit had the longest and significantly greater bout length than other avian visitors ($\bar{x}$ 1233. 18 sec $\pm$ 1041.07 SD, P $\geq$ 0.002, 2-tailed Mann-Whitney U test). Small Green Barbet and Coppersmith Barbet had similar (P > 0.20) but moderate lengths of feeding bouts, often lasting ten to fifteen minutes. Crow, Tree Pie, Common Myna, Golden Oriole, Red-whiskered Bulbul, Redvented Bulbul and Tickell's Flowerpecker all had much shorter feeding bouts of three to six minutes durations. There was significant difference between the specialists and the opportunists (U = 0, P > 0.002).

The relative number of successful feeding bouts varied considerably among different bird species. The Small Green Barbet and Coppersmith Barbet with over 95% success rates were the most successful species at _F. religiosa_ crop. Both were residents and fruit-eating specialists. The specialists like the Koel, the Common Green Pigeon and opportunists such as the Golden Oriole and the Common Myna also were highly successful visitors (Fig. 9). The jungle Crow, Redwhiskered Bulbul, Redvented Bulbul, Tree Pie, Blackheaded Oriole and Flowerpecker had slightly lower and similar numbers of successful bouts (P > 0.30, chi-square tests). The House Crow had the lowest success rate (Fig. 9).

The differential lengths of time spent per visit (Table 18 and Fig. 6) and rates of successful feeding bouts (Table 19 and Fig. 9)

62·13

Fig. 8. Percent successful feeding bouts of different frugivore species on (a) *F. exasperata* (b) *F. amplissima* (Tenhipalam site)


A
120
100
80
60
40
20
0
ES MV MH TP TR PC CM CS AT DV OO OX
Success Rate
B
120
100
80
60
40
50
0
ES MV MH TD PC CM CS AT DV OO OX
Bird Species

of 9 bird species visiting the fruiting crown of *F. tsjahela* were estimated. The specialist such as small Green Barbet, Coppersmith Barbet, Common Green Pigeon and Greyfronted Green Pigeon had similar bout lengths ($P > 0.30$) and each of them spent up to thirty to thirty five minutes per bout. They had significantly greater visitation lengths than the opportunists ($P < 0.02$ M-W U test). The Golden Oriole foraged as long as ten to twelve minutes while the Blackheaded Oriole and the Tickell's Flowerpecker spent four to five minutes only. The Jungle Crow had a mean visitation length of 220.74 seconds.

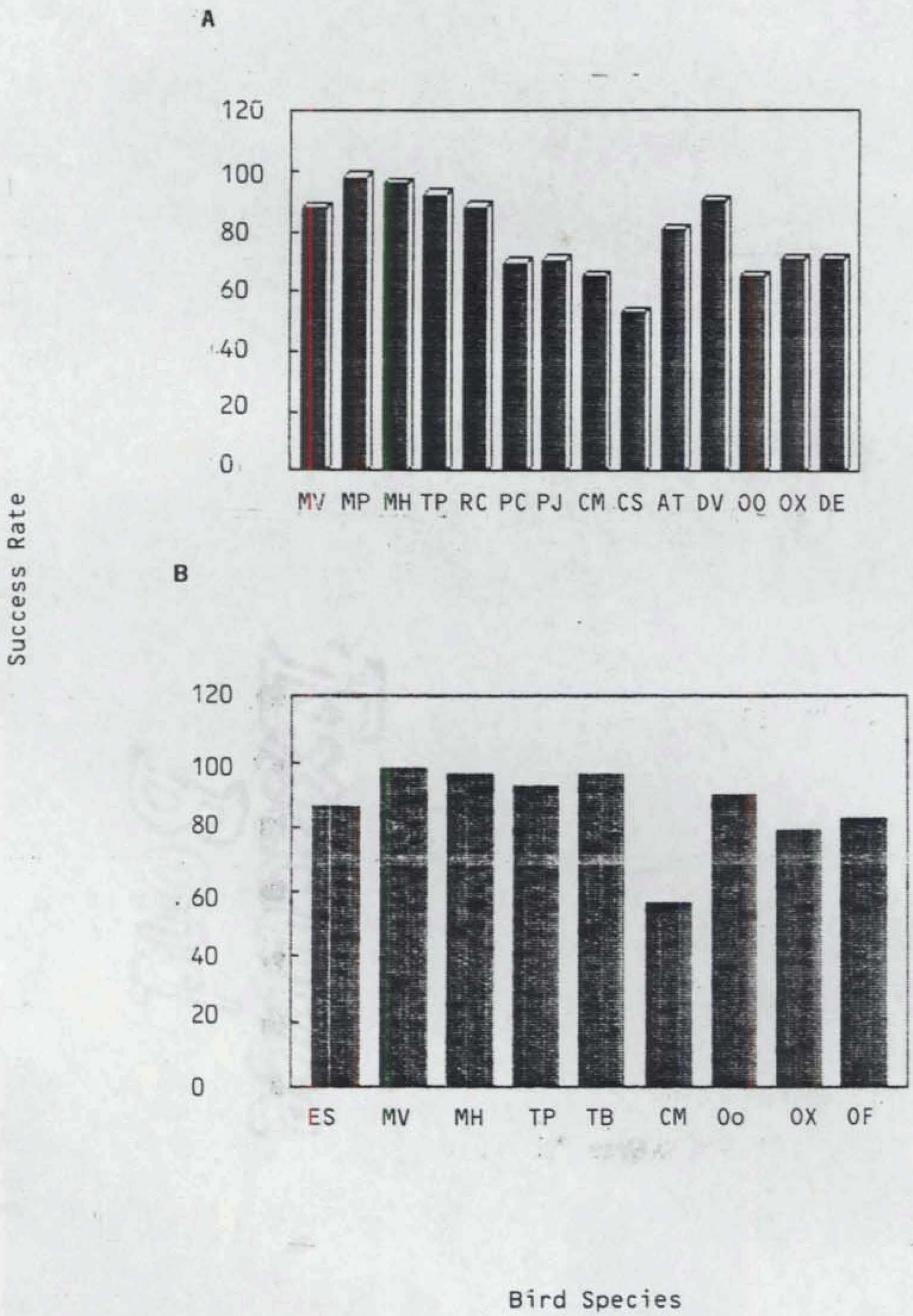
The Fig. 9 and Table 19 depicts the relative proportion of successful attempts of various bird species at *F. tsjahela*. The Small Green Barbet and the fruit Pigeons with over 95% of successful feeding visits were the most successful species. The Koel had only 86% success rate at this fig. The Golden Oriole was successful in 90% of feeding bouts. The Blackheaded oriole and Tickell's Flower-pecker achieved 78.94% and 82.76% success rates respectively while the Jungle Crow registered a low 56.25% success rate.

Feeding Rate

The number of figs eaten per minute varied considerably in different avian frugivores. Birds like the small Green Barbet and

63'

Fig. 9. Success rates of feeding bouts of different bird species at *F. religiosa* and *F. tsjahela*.


A
B
Success Rate
Bird Species
0
20
40
60
80
100
120
MV MP MH TP RC PC PJ CM CS AT DV OO OX DE
ES MV MH TP TB CM Oo OX OF

the Koel often swallowed figs whole or after a brief manipulation by bill. Others like Green Pigeon or Parakeets had a piece-meal diet.

The relative fig consumption rates of fourteen species of birds eating F. benghalensis crop were estimated and are as given in Table 13. The Small Green barbet and the Koel had similar (U = 947; P > 0.50; Mann-Whitney U test) but significantly greater feeding rates than other bird species (P < 0.002). The Common Green Pigeon, Coppersmith Barbet, Jungle Crow, House Crow, Golden Oriole, Common Myna, and Tree Pie had relatively lower and similar rates of feeding (Table 13; P > 0.30). The Blossomheaded Parakeet, Roseringed Parakeet, Blackheaded Oriole, Grey headed Myna, and Large Indian Cuckoo Shrike ate the large sized figs of F. benghalensis only very slowly (Table 13).

At F. exasperata, the relative feeding rates were estimated in respect of eleven bird species (Table 14). The Koel and Small Green Barbet had similar feeding rates ($\bar{x}$ 0.57 $\pm$ 0.42 ; $\bar{x}$ 0.51 $\pm$ 0.34 figs per minute respectively). They however, had significantly greater feeding rates than other avian frugivores. (P < 0.002; Mann-Whitney U test). The common and the Greyfronted Green Pigeons consumed these figs at an almost equal rate (Table 14). The Coppersmith Barbet ($\bar{x}$ 0.19 $\pm$ 0.13 figs/min.) was much slower than the Small Green Barbet. Similar and lower feeding rates were observed in Jungle crow, House

Crow, Common Myna, Golden Oriole, Blackheaded Oriole and Tree Pie (Table 14). The Black headed Oriole having an average consumption rate of 0.13 figs per minute was the slowest foraging species in the present study.

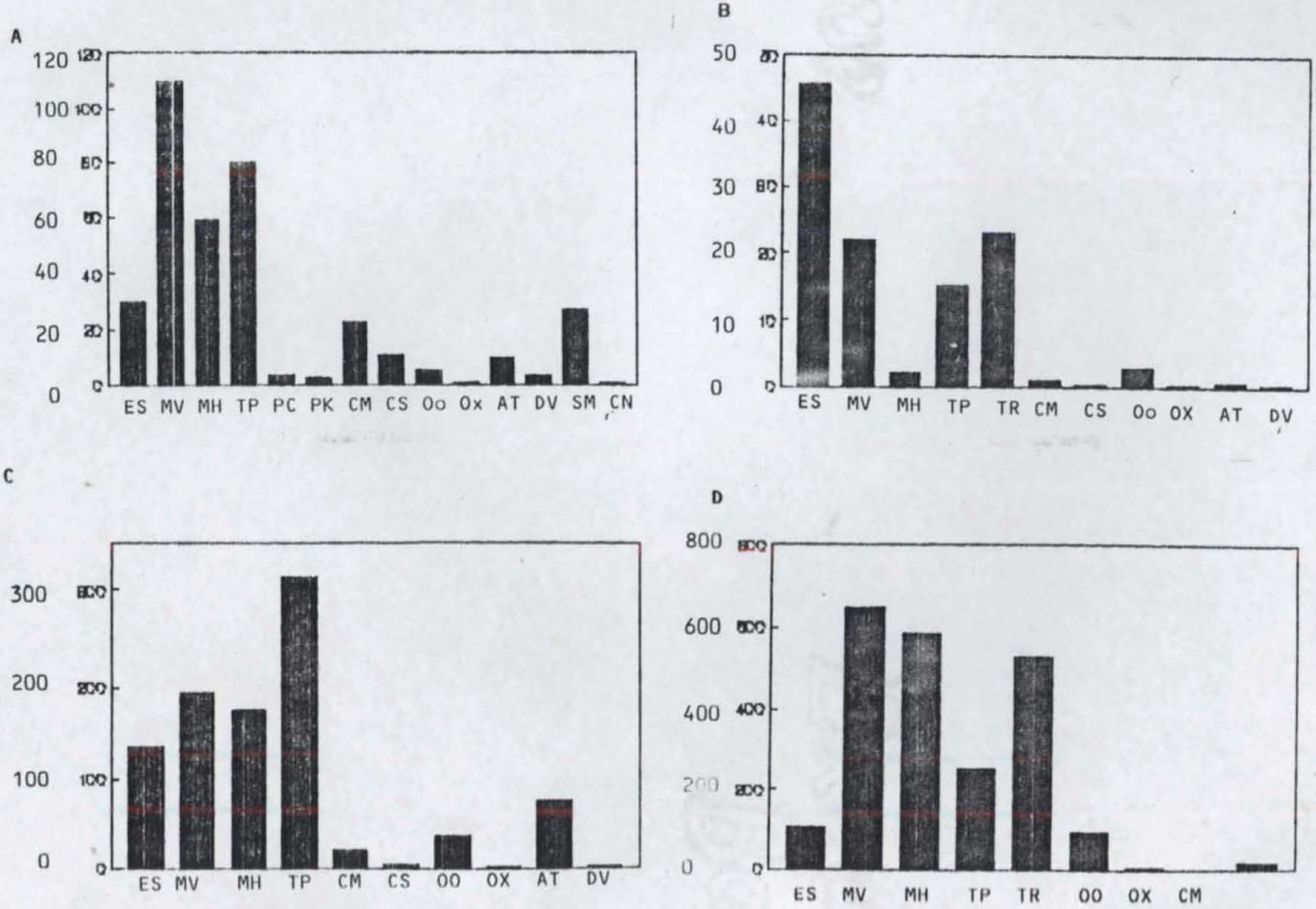
The *F. racemosa* figs are relatively large in size and are easily dropped as the birds pecked at them. So the avian frugivores required greater efforts and handling time at this fig. The Koel consumed up to five figs in a visit and was the fastest consumer ($\bar{x}$ 0.37 $\pm$ 0.33 fig/min.). The Small Green Barbet also had a relatively higher consumption rate ($\bar{x}$ 0.35 $\pm$ 0.43 figs/minute.). Green Pigeons, Crows and Coppersmith Barbet had slightly lower and similar feeding rates (Table 15; $P > 0.30$ Mann-Whitney U test).

Table 16 describes the average feeding rates of ten frugivore species on *F. amplissima*. The Koel and the Common Green Pigeon had greater ($\bar{x}$ 1.31 $\pm$ 1.26; $\bar{x}$ 1.25 $\pm$ 0.79 figs/min. respectively) and similar feeding rates ($P > 0.50$, Mann-Whitney U test). The Small Green Barbet differed significantly from Coppersmith Barbet in the rate of feeding ($U = 959$; $P < 0.05$, 2 tailed Mann-Whitney U test). The Golden Oriole and the Common Myna consumed an average 0.66 and 0.57 figs/minute repectively while the Blackheaded Oriole and the Jungle Crow had slightly lower feeding rates (Table 16). The House Crow and the Tree pie had almost equal rates of consumption ($\bar{x}$ 0.40 $\pm$ 0.34; $\bar{x}$ 0.43 $\pm$ 0.34 fig/min. respectively). The specialists had significantly higher feeding rates than the oportunists ($P < 0.001$, 2 tailed M-W U test).

At F. religiosa the average feeding rates of thirteen species of birds were compared (Table 17). The Koel, Common Green Pigeon, Small Green Barbet, Coppersmith Barbet etc; swallowed these figs whole. They were very fast eating and had similar rates of feeding ($P > 0.30$). The Common Myna, Golden Oriole, and Blackheaded Oriole had slightly lower and similar feeding rates (Table 17). The Jungle crow and House crow were also rather slow eating with an average 0.57 and 0.56 figs consumed per minute respectively. The Redvented and Redwhiskered Bulbul ate average 0.79 and 0.74 figs per minute respectively.

The feeding rates of nine important avian visitors at F. tsiahela crop were considered in the present study (Table 18). The fruit pigeons and the Small Green Barbet had higher and similar rates of feeding ($P > 0.30$; 2 tailed Mann-Whitney U test). The coppersmith Barbet ate a mean 2.23 figs per minute. These four specialists were significantly faster consumers than others ($P < 0.01$). The Koel ate an average 1.81 figs per minute. The Golden Oriole consumed a more or less similar number of figs per minute as that of Koel (Table 18). The mean feeding rates were similar for Blackheaded Oriole and Tickell's Flowerpecker ($P > 0.30$). The Jungle Crow which ate an

Fig. 10. Fruit removal rates of important avian frugivores on *F. benghalensis*, *F. exasperata*, *F. amplissima* and *F. tsjahela*.



Bird Species

average 0.41 figs per minute was the slowest of nine species studied (Table 19).

Fruit Removal Rate

The fruit removal rate by a bird species ie; the number of figs consumed by the species in an hour of observation is used as a measure of interaction between the fruigivore and the fruiting plant species. It is estimated as the product of means of group size, visitation rates, visitation length and feeding rates. No estimate was made of the amount of figs dropped either via disturbance by foragers or in winds.

The differential rates of fruit removal at F. benghalensis in respect of fourteen different bird species were determined (Table 13). The Small Green barbet in Small groups had eaten the greatest number of figs per hour ($\bar{x}$ 109.46 figs/hour). It differed significantly from Coppersmith Barbet ($x^2 = 13.14$, $P < 0.001$) and Koel (x^2 46.26, $P < 0.001$) and Common Green Pigeon ($x^2 = 4.60$; $P < 0.05$). Coppersmith Barbet and Green pigeon had similar removal rates ($P > 0.30$) but both had consumed significantly greater number of figs per hour than the Koel ($P > 0.001$, chi-square test). The Blossom headed and Rose-ringed parakeets were less frequent and slow eaters and thus could harvest only a few figs (3.50 and 2.39 figs/hour respectively).

The opportunists generally showed a lower rate of fruit removal (Fig 10). They performed relatively shorter visits and fewer number of visits per hour. The Jungle Crow and the Grey-headed Myna which foraged in larger numbers had removed 22.44, and 27.02 figs per hour respectively. The House Crow removed a lesser number of figs than the Jungle Crow (Fig. 10). The Common Myna removed a similar number of figs as the House Crow ($P > 0.30$). The Golden Oriole ate an average 4.98 figs per hour while the Large Indian Cuckoo Shrike and the Blackheaded Oriole had the lowest fruit removal rates (> 1 figs/hour) among the fourteen species of birds studied.

At F. exasperata the fruit removal rates of eleven important avian frugivores were estimated (Table 14). The highest fruit removal rate was observed in Koel ($\bar{x}$ 45.50 figs/hour). The Common Green Pigeon, Greyfronted Green Pigeon and Small Green Barbet had more or less similar rates of removal ($P > 0.30$). The lowest fruit removal rate among the specialists was found in the Coppersmith Barbet (Fig. 10). The specialists removed about 93.87% of total figs consumed in an hour by the avian assemblage. There was significant difference in the fig removal rates between specialists and opportunists ($x^2 = 91.50, P < 0.001$). The Golden Oriole and the Jungle Crow which ate average 2.91 and 1.15 figs/hour were the prominent opportunists (Table 14). The Common Myna, Blackheaded Oriole, House Crow and Tree Pie, each of which removed only a low average of less than one fig in an hour of observation, were found to be very insignificant visitors at F. exasperata.

Table 15 and figure 7 describe birds at F. racemosa. The removal rates were generally low in all the species observed. The Koel and the Common Green Pigeon removed average 5.44 and 5.43 figs per hour respectively. The Small Green Barbet harvested an average 3.84 figs/hour., while its congeneric species, the Coppersmith Barbet ate an average 0.12 figs only in an hour of observation. The rate of fig removal by the Jungle Crow and the House Crow was 2.85 and 2.66 respectively.

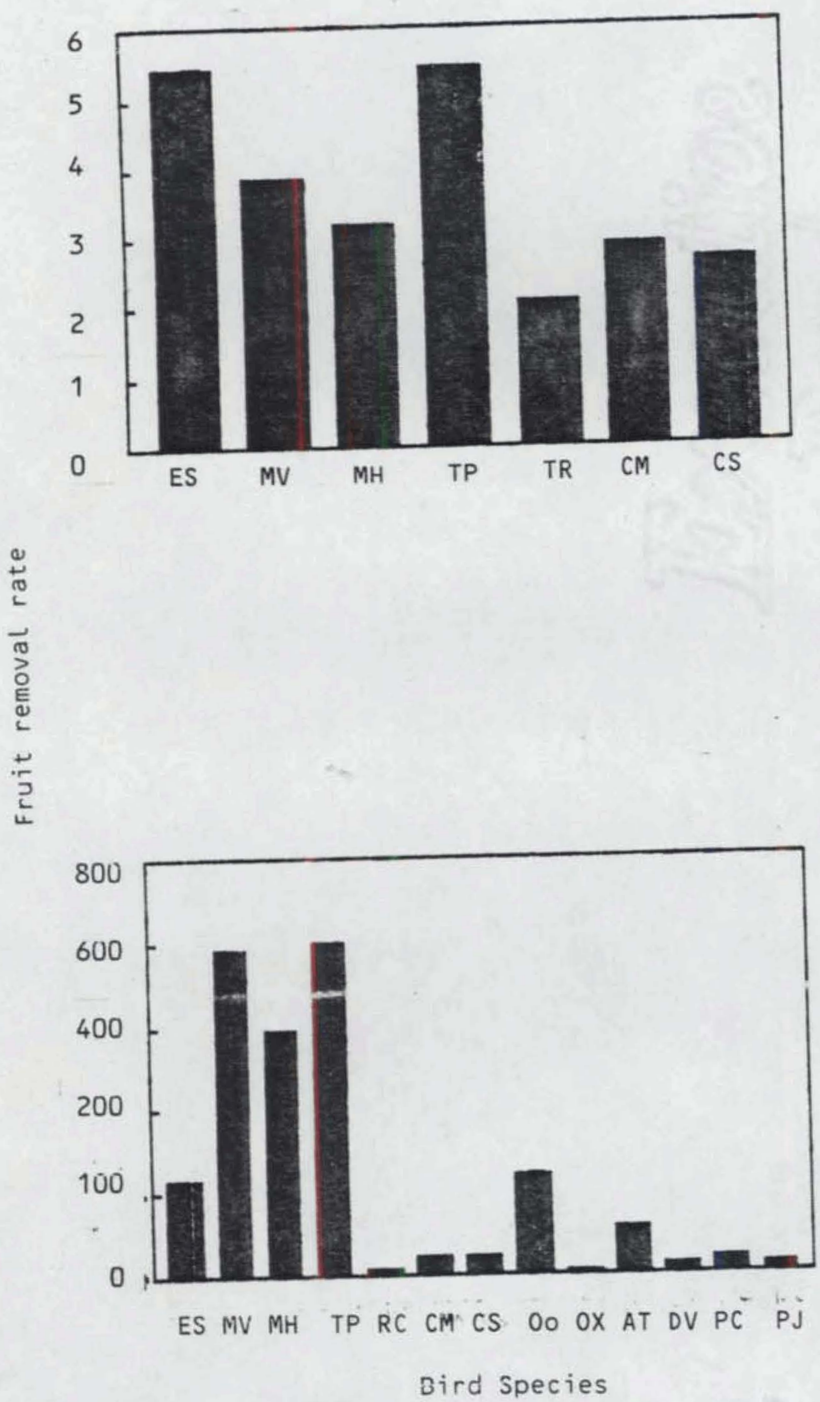
At F. amplissima the common Green Pigeon (T. phoenicoptera) removed significantly greater number of figs per hour ($\bar{x}$ 315 figs/hour, $P < 0.001$, chi-square test). The Small Green Barbet (M. virdis) and the Coppersmith Barbet (M. haemacephala) consumed mean number of 192.30 and 176.21 figs/hour respectively while the Koel (E. scolopacea) had a slightly lower rate of fruit removal (Table 16). These four specialists accounted for over 85% of total figs removed by ten species of birds in the present study. Among the opportunists, the Common Myna (A. tristis) removed significantly greater number of figs per hour of observation ($\bar{x}$ 75.53 fig/hr. $P < 0.001$) followed by the Golden Oriole (O. oriolus; table 16). The Jungle Crow (C. macrorhyncos) had significantly higher removal rate than the House Crow (C. splendens) $x^2 = 12.36$; $P < 0.001$). Tree Pie

(*D. vagabunda*) and Blackheaded Oriole (*O. xanthornus*) also had much lower rates of removal (Fig. 10) and were rather insignificant dispersers of *F. amplissima* seeds.

The relative fruit removal rates of thirteen species of birds utilising *F. religiosa* crops were estimated (Table 17, Fig. 11). The group of Common Green Pigeon which ate an average 401 figs per hour had the highest fruit removal rate. The Small Green Barbet and the Coppersmith barbet also removed a greater proportion of figs in an hour of observation ($\bar{x}$ 390.89 and $\bar{x}$ 295.57 figs/hour respectively). The Koel with a mean group size of 2.91 birds at this fig removed an estimated 116.80 figs/hour. These four specialised frugivores together harvested 82.74% of the total crop removed by avian visitors in an hour of observation. The Blossom-headed Parakeet with a low and mean fruit removal rate of 9.36 figs/hour was least important of the Seven specialists dependent on *F. religiosa* crop. Red-vented Bulbul (*P. cafer*) and Redwhiskered Bulbul (*P. jocosus*) had slightly higher fruit removal rate than Parakeets (Fig. 11).

Among the opportunists the Golden Oriole and the Common Myna were the most prominent fig consumers which removed an estimated 91.69 and 82.23 figs/hour respectively. The Jungle Crow, House Crow and Tree Pie had much lower and similar removal rate (Table 17). The

Fig. 11. Fruit removal rates of important bird species attending (A) _F. racemosa_, (B) _F. religiosa_



Fruit removal rate
6
5
4
3
2
1
0
ES MV MH TP TR CM CS
800
600
400
200
100
0
ES MV MH TP RC CM CS Oo OX AT DV PC PJ
Bird Species

Blackheaded Oriole with a mean removal rate of 6.53 figs/hour was the least important of the thirteen bird species studied on F. religiosa (Fig. 11).

Table 18 gives the differential fruit removal rates of nine avian frugivores at F. tsjahela. The specialists such as Small Green Barbet, Coppersmith Barbet, Common Green Pigeon, Grey-fronted Green Pigeon and Koel together contributed for the removal of over 90% of total figs per hour. They were the most important consumers at this fig. Small Green Barbets harvested the maximum number of figs in an hour (651.61 figs). Copper Smith Barbet and Greyfronted Green Pigeon had similar rates of removal (Table 18). The latter, however removed much larger number of figs than its congener, the common Green Pigeon (530.87 and 250. 76 figs/hour respectively). The Koel removed on average 110.70 figs in an hour of observation.

The Golden Oiole had the greatest fruit removal rate among the opportunists (Fig. 10). The Tickell's Flowerpecker and Blackheaded Oriole ate 13.68 figs and 4.67 figs per hour respectively. The Jungle Crow had the lowest removal rate among the nine species of birds studied (Fig. 10).

Plate 13. _Ficus exasperata_ fruiting crown

a. Koel mandibulating a ripe fig.

b. Golden Oriole at feeding activity.

PLATE 13

a

b

B. Vythiri Site

Frequency of occurrence

Seventeen species of birds were observed feeding on F. exasperata crop. Observations were conducted for a total of 108 hours on twelve different trees in this area. The avian frugivores attending this fig comprised ten specialists and seven opportunists (Table 11). Sixty six bird activity censuses were carried out during the study period between December 1990 and December 1992.

The frequencies of occurence of fourteen bird species were studied (Table 20). The specialists, fruit pigeon T. pompadara and barbet M virdis and M. rubricapilla were observed much more frequently than others. They occurred in 36, 40 and 35 censuses respectively. The Hornbill T. griseus was present in 14, the Imperial Pigeon D. badia and the Parakeet P. columboides in 10 of 66 censuses. The Black Bird (T. merula) had 15.5% attendance (10 censuses). The Redwhiskered Bulbul (P. Jocosus) also had a high frequency of occurrence (40.91%). The White Eye (Z. palpebrosa) was observed in 24.24% of censuses while other opportunists Hill Myna (G. religiosa), Blue Bird (I. puella) Oriole (O. oriolus) and specialists such as Black Bulbul (H. madagascariensis) Yellowbrowed Bulbul (H. indicus) had much lower and similar frequencies of occurrence (Table 20). The thrushes Z. citrina, M. solitarius and Lorikeet Loriculus vernalis were rarely seen visitng this fig.

At the fruting crown of *Ficus nervosa* the avian frugivore activity was monitored for a total of 84 hours. Eight different trees of this species were observed and altogether Sixty two bird activity censuses were undertaken. Fourteen different species of birds foraged on this fig. They included nine specialists and five opportunists.

The Small Green Barbet having a frequency of occurrence 67.74% (42 censuses) was the commonest visitor at this fig species. It was significantly more frequent than the Greyfronted Green Pigeon which occurred in 29 censuses (x^2 3.84, P = 0.05). The Crimsonthroated Barbet with an attendance of 62.90% (39 censuses was also a common visitor, at *F. nervosa*. The Malabar Grey Hornbill, Bluewinged Parakeet, Black Bulbul and Redwhiskered Bulbul had similar and relatively low frequencies of occurrence (Table 20). The Imperial Pigeon and Black Bird were observed in 8 each and the Bluerock Thrush in 6 censuses respectively. The Yellowbrowed Bulbul, Whitethroated Ground Thrush were found in less than 10 % of observations only.

The avian assemblage at *F. beddomei* fruiting crown consisted of Sixteen species. Twenty two different trees of this fig species were surveilled for approximately 126 hours. One hundred and twenty bird censuses were carried out during this study. Most of the avian frugivores had less preference to this fig. There were eleven specialists and five opportunists attending to this crop (Table 11).

TABLE 20. **Comparative frequencies of occurrence of important avian frugivores on various fruiting *Ficus* species in the Vythiri Site.**

Data are percentages of observations. Data in parentheses (1) total number of bird activity censuses (2) Number of occurrence of each bird species. Bird species with below 5% observations were not considered).

Sl. No.	Bird Taxon	*F. tsjahela* (89)[1]	*F. microcarpa* (66)	*F. amplissima* (112)	*F. exasperata* (66)	*F. nervosa* (62)	*F. beddomei* (120)
1.	*T. pompadora*	24.72 (22)[2]	31.82 (21)	64.29 (72)	54.55 (36)	46.67 (29)	58.33 (70)
2.	*D. badia*	--	--	21.43 (24)	12.12 (8)	14.52 (9)	25.83 (31)
3.	*T. griseus*	--	--	28.09 (25)	21.21 (14)	19.35 (12)	27.50 (33)
4.	*M. virdis*	50.56 (45)	53.03 (35)	67.86 (76)	60.61 (40)	67.74 (42)	47.50 (57)
5.	*M. rubricapilla*	58.43 (52)	59.09 (39)	75 (84)	53.03 (35)	62.90 (39)	46.67 (56)
6.	*P. columboides*	--	22.73 (15)	41.57 (37)	9.09 (6)	17.74 (11)	21.67 (26)
7.	*T. merula*	26.97 (24)	24.24 (16)	18.75 (21)	15.15 (10)	16.13 (10)	14.17 (17)
8.	*P. jocosus*	17.98 (16)	27.27 (18)	21.43 (24)	40.91 (27)	20.97 (13)	--
9.	*H. madagascariensis*	43.82 (39)	39.39 (26)	46.43 (52)	18.18 (12)	17.74 (11)	11.67 (14)
10.	*H. indicus*	30.34 (27)	21.21 (14)	24.10 (27)	10.61 (7)	6.45 (4)	10.00 (12)
11.	*G. religiosa*	17.98 (16)	25.76 (17)	37.50 (42)	18.18 (12)	11.29 (7)	18.33 (22)
12.	*O. oriolus*	17.98 (16)	--	26.79 (30)	10.61 (7)	--	10.00 (12)
13.	*I. puella*	19.10 (17)	25.76 (17)	20.54 (23)	13.64 (9)	12.90 (8)	10.00 (12)
14.	*Z. palpebrosa*	20.22 (18)	28.79 (19)	19.64 (22)	24.24 (16)	6.45 (4)	--
15.	*D. erythrorhynchos*	24.72 (22)	--	--	--	--	--
16.	*D. concolor*	20.22 (18)	28.79 (19)	26.79 (30)	--	--	--
17.	*M. solitarius*	16.85 (15)	--	--	--	9.68 (6)	5.00 (6)
18.	*Z. citrina*	--	--	--	--	6.45 (4)	--
19.	*Phylloscopus trochiloides*	20.22 (18)	--	--	--	--	--
20.	*Carpodacus erythrinus*	--	--	--	--	--	5.00 (6)

The differential frequencies of occurrence of twelve bird species were estimated in the present study. The Fruit Pigeon and barbets were more commonly seen visiting this fig species. The Green Pigeon (*T. pompadora*) had the highest frequency of occurrence (58.33%). It differed significantly from other species of birds ($P < 0.001$, Chi-square test). The Small Green Barbet and Crimsonthroated Barbet were present in 57 (47.50%) and 56 (46.67%) censuses respectively. The larger frugivores like the Imperial Pigeon and the Malabar Grey Hornbill had relatively lower attendances (25.83%, 27.50% respectively). The Blue-winged Parakeet, Black Bird and Hill Myna had almost similar frequencies of occurrence (Table 20, $P < 0.01$ chi-square test). The Black Bulbul and Yellowbrowed Bulbul were present in 14 and 12 censuses respectively at this fig crop. The Golden Oriole and the Blue Bird had much lower attendances (Table 20). The Rose Finch (*carpodachus erythrinus*), and the Blue Rock Thrush (*Monticola solitarius*) were rarely observed visiting this fig.

Table 11 describes the avian visitors at *F. amplissima*. The foraging activity of avian frugivores was studied for approximately 140 hours during 1990-1992 period. One hundred and twelve bird activity censuses were carried out on eighteen trees of this *Ficus* species. Twenty two species of birds utilised the crop. There were ten specialists and twelve opportunists. The lorikeet and Rose Finch were rare visitors.

The relative frequencies of occurrence of fifteen important bird species were accounted in this study (Table 20). Small Green Barbet and Crimsonthroated Barbet were commoner visitors having about 65 to 75 % attendance. The Bluewinged Parakeet had 41.57% attendance while the Imperial Pigeon, Malabar Grey Hornbill and Black Bird were slightly less frequent at F. amplissima (Table 20). The Black Bulbul (46.43%) had significantly greater attendance than either the Redwhiskered Bulbul (x^2 = 10.10, P < 0.01) and the Yellowbrowed Bulbul (x^2 = 7.90, P < 0.01). The Hill Myna with an attendance of 37.50% (42 censuses) was the most frequent opportunists. The Blue Bird, White Eye, Golden Oriole and Flowerpecker (Dicaeum) had relatively lower and similar attendances (Table 20).

Table 11 shows various bird species utilising the crop of F. microcarpa. The avian foraging activity at this fig species were studied for approximately 117 hours during the study period. Sixteen different avian frugivores ate this fig. There were eight specialists and eight opportunists. A total of Sixty Six bird activity censuses were conducted on twelve different trees in this area.

The frequenciesof occurrence of twelve bird species were estimated (Table 20). The most frequently occuring frugivores were the Small Green Barbet and the Crimson-throated Barbet (35 and 39 censuses respectively). They differed significantly from all other avian visitors at _F. microcarpa_. (x^2 32.92 $P < 0.001$). The Grey fronted Green Pigeon was present in 21 of 66 censuses (31.62%) and the Black Bird in 16 censuses (24.24%). The Black Bulbul had 39.39% attendance (26 censuses). The Hill Myna, Blue Bird, Yellow-browed Bulbul, White Eye, Red-whiskered Bulbul and Flowerpeckers had similar visitation patterns (Table 20).

Avian foraging activities were observed on thirteen different trees of _F. tsjahela_ in the vatappara study area. The avian assemblage attending fig crops comprised sixteen species of birds. Monitoring was carried out for approximately 103 hours between December 1990 and December 1992. The guild of frugivores included seven specialists and nine opportunists. Altogether eighty nine bird activity censuses were undertaken during this period.

The Small Green Barbet and the Crimsonthroated Barbet were present in 45 (50.56%) and 52 (58.43%) censuses respectively. Both had significantly greater frequencies of occurrence than the Greyfronted Green Pigeon ($x^2 = 8.87$, $P < 0.01$; $x^2 = 13.66$, $P < 0.001$ respectively). The Black Bulbul with a frequency of occurrence 43.82% also differed significantly from the Green Pigeon (24.72% attendance $= x^2 = 4.74$, $P < 0.05$). The Redwhiskered Bulbul, Golden Oriole, Hill Myna, White eye, Blue Rock Thrush and Nilgiri Flowerpecker had more or less similar frequencies of occurrence (nearly 20%). The Black bird and Tickell's Flowerpecker had much lower attendance at this fig during this study (Table 20).

Frequency of visits

The utilization of F. exasperata crop by nine important species of birds were studied in detail. The table 21 showed differential visitation rates of these birds. The Small Green Barbet, the Crimson throated Barbet and the Redwhiskered Bulbul had higher rates of visits (Table 21). The Small Green Barbet was significantly more frequent than the Greyfronted Green Pigeon ($U = 11.50$, $P < 0.05$, 2 tailed Mann-Whitney U test). The Green Pigeon and the Malabar Grey Hornhill made average 1.43 ± 0.90 and 0.73 ± 0.71 visits/hour respectively. The white eye visited average 1.23 times in an hour of observation while Hill Myna, Blue Bird and Black Bulbul had much lower and similar visitation rates (Table 21).

Table 22 describes the mean visitation frequencies of six important avian species exploiting F. nervosa crop. The Small Green Barbet had the highest mean visitation rate ($\bar{x}$ 3.54 ± 2.85 visits/hour) while the Crimsonthroated Barbet was slightly less frequent ($\bar{x}$ 3.11 ± 2.77 visits/hour). The Greyfronted Green Pigeon foraged an average 1.24 times per hour. All these three species had much greater visitation rates than Black Bulbul, Redwhiskered Bulbul and Black Bird (Table 22). The latter three species made average 0.8, 0.86 and 0.27 visits per hour respectively.

At *F. beddomei*, the visitation patterns of seven species of birds were studied in detail. The Fruit Pigeon and the Small Green Barbet with mean visiation rates 1.60 and 1.52 respectively had significantly greater visitation frequency than other foragers ($P < 0.05$, M-W U test, Table 23) except the Crimsomthroated Barbet ($\bar{x}$ 1.07 $\pm$ 0.65 visits per hour). The Malabar Grey Hornbill, Jerdon's Imperial Pegeon and Bluewinged Parakeet had relatively lower and similar visitation pattern at this fig (Table 23, $p > .30$)

The differential visitation rates of twelve species of birds attending *F. amplissima* are given in table 24. The Crimsonthroated Barbet which made up to 12 visits per hour had the highest visitation rate. It differed significantly from small Green Barbet ($U = 29$, $P < 0.05$) and Greyfronted Green Pigeon ($U = 3$, $P < 0.001$). The small Green Barbet and Black Bulbul had moderately high and similar visitation rates (Table 24, $U = 49.5$, $P > 0.40$). They made upto 8 visits each in on hour of observation. The Greyfronted Green Pigeon made slightly lesser number of visits per hour ($\bar{x}$ 1.89 $\pm$ 0.79 visits/hour). It had however, much more feeding visits than the Hornbill and Imperial Pigeon (Table 24). The latter two species were rather infrequent making only less than one visit in an hour. A specialised frugivore, the Black Bird also had much lower visitation

TABLE 21. **Group size, Visitation length, Visitation rate, Feeding rate and Fruit removal rate of important avian frugivores attending *F. exasperata* (Vythiri Site)** (Figures are means with standard deviation. Data in parenthesis is number of samples).

Sl. No.	Bird species	Group size	Visitation length	Visitation rate	Feeding rate	Fruit removal rate
1.	*T. pompadora*	5.84 ± 4.20 (26)	441.37 ± 186.20 (19)	1.40 ± 0.90 (8)	0.31 ± 0.15 (18)	19.04
2.	*M. virdis*	4.24 ± 2.40 (25)	228.24 ± 99.63 (17)	2.64 ± 1.02 (8)	0.57 ± 0.26 (14)	24.27
3.	*M. rubricapilla*	5.76 ± 4.27 (29)	177.17 ± 110.53 (30)	2.94 ± 1.96 (8)	0.21 ± 0.15 (25)	10.50
4.	*T. griseus*	2.00 ± 1.77 (8)	701.92 ± 337.83 (13)	0.73 ± 0.71 (8)	1.96 ± 1.63 (13)	33.48
5.	*H. madagascariensis*	5.57 ± 4.04 (13)	121.18 ± 69.85 (11)	0.60 ± 0.80 (8)	0.13 ± 0.11 (10)	0.88
6.	*P. jocosus*	3.82 ± 2.37 (27)	97.17 ± 93.64 (35)	2.96 ± 1.85 (8)	0.12 ± 0.11 (35)	2.19
7.	*G. religiosa*	4.63 ± 2.13 (8)	14.33 ± 49.69 (9)	0.56 ± 0.61 (8)	0.23 ± 0.15 (10)	1.24
8.	*Z. palpebrosa*	13.40 ± 9.83 (20)	137.62 ± 65.62 (21)	1.23 ± 1.28 (8)	0.10 ± 0.07 (23)	3.78

TABLE 22. **Group size, Visitation length, Visitation rate, Feeding rate and Fruit removal rate of various avian frugivores at *F. nervosa* (Vythiri site)** (Figures are with means with standard deviation. Sample sizes in brackets).

Sl. No.	Bird species	Group size	Visitation length	Visitation rate	Feeding rate	Fruit removal rate
1.	*T. pompadora*	4.38 ± 3.25 (13)	473.89 ± 234.71 (18)	1.24 ± 1.02 (9)	0.62 ± 0.34 (18)	26.54
2.	*M.virdis*	6.05 ± 3.28 (20)	266.96 ± 180.90 (27)	3.54 ± 2.85 (9)	1.08 ± 0.47 (27)	102.91
3.	*M. rubricapilla*	7.43 ± 3.79 (21)	290.00 ± 165.89 (36)	3.11 ± 2.77 (9)	0.40 ± 0.39 (36)	44.67
4.	*T. merula*	1.83 ± 0.98 (7)	156.11 ± 77.68 (9)	0.27 ± 0.35 (9)	0.51 ± 0.36 (9)	0.66
5.	*H. madagascariensis*	5.6 ± 3.47 (10)	167.13 ± 88.76 (15)	0.86 ± 0.86 (9)	0.08 ± 0.09 (15)	1.07
6.	*P. jocosus*	3.20 ± 2.30 (10)	144.18 ± 100.58 (11)	0.82 ± 1.20 (9)	0.12 ± 0.12 (11)	0.76

TABLE 23. **Group size, Visitation length, Visitation rate, Feeding rate and Fruit removal rate of various avian frugivores at *F. beddomei*** (Figures are means with standard deviation)

Sl. No.	Bird species	Group size	Visitation length	Visitation rate	Feeding rate	Fruit removal rate
1.	*T. pompadora*	8.03 ± 5.05 (30)	537.16 ± 329.94 (49)	1.60 ± 0.89 (11)	0.17 ± 0.13 (44)	20.21
2.	*M. virdis*	3.67 ± 3.44 (23)	240.27 ± 173.48 (51)	1.52 ± 0.71 (11)	0.18 ± 0.15 (52)	4.02
3.	*M. rubricapilla*	3.83 ± 2.60 (18)	196.84 ± 144.06 (31)	1.07 ± 0.65 (11)	0.10 ± 0.11 (25)	1.34
4.	*Tockus griseus*	2.92 ± 1.75 (13)	439.06 ± 207.52 (16)	0.67 ± 0.76 (11)	0.55 ± 0.33 (15)	7.87
5.	*D. badia*	3.55 ± 2.70 (20)	621.55 ± 295.26 (11)	0.82 ± 0.72 (11)	0.25 ± 0.14 (10)	7.54
6.	*P. columboides*	2.67 ± 1.56 (12)	745.73 ± 515.20 (11)	0.45 ± 0.37 (11)	0.07 ± 0.05 (11)	1.05
7.	*G. religiosa*	4.60 ± 3.41 (10)	230.00 ± 143.11 (11)	0.49 ± 0.63 (11)	0.07 ± 0.08 (11)	0.60

TABLE 24. **Group size, Visitation length, Visitation rate, Feeding rate and Fruit removal rate of important avian frugivores at *F. amplissima* (Vythiri Site).** (Figures are means with SD. Sample sizes in brackets)

Sl. No.	Bird species	Group size	Visitation length	Visitation rate	Feeding rate	Fruit removal rate
1.	*T. pompadora*	15.63 ± 10.04 (30)	363.89 ± 287.05 (56)	1.89 ± 0.79 (11)	2.41 ± 1.64 (47)	431.77
2.	*M. virdis*	11.63 ± 5.65 (30)	287.90 ± 253.22 (30)	3.88 ± 1.59 (11)	2.98 ± 1.36 (31)	645.24
3.	*M. rubricapilla*	21.48 ± 9.65 (40)	263.67 ± 213.89 (64)	5.80 ± 2.39 (11)	1.94 ± 1.14 (69)	1062.12
4.	*T. griseus*	2.17 ± 1.19 (17)	414.29 ± 205.74 (14)	0.55 ± 0.63 (11)	4.96 ± 3.71 (15)	40.87
5.	*D. badia*	3.11 ± 2.83 (20)	476.14 ± 205.33 (14)	0.53 ± 0.67 (11)	3.01 ± 1.61 (12)	39.37
6.	*T. merula*	2.07 ± 0.80 (15)	242.08 ± 182.65 (13)	0.65 ± 0.86 (11)	1.30 ± 0.69 (16)	7.06
7.	*H. madagascariensis*	8.35 ± 5.82 (29)	167.74 ± 127.30 (58)	3.64 ± 2.30 (11)	1.09 ± 1.04 (54)	92.62
8.	*H. indicus*	2.36 ± 1.57 (11)	10.1 ± 59.70 (17)	0.59 ± 0.69 (11)	1.12 ± 1.16 (19)	2.63
9.	*P. jocosus*	6.55 ± 2.91 (11)	136.45 ± 82.64 (33)	1.86 ± 1.79 (11)	0.82 ± 0.54 (32)	22.72
10.	*G. religiosa*	7.35 ± 4.40 (26)	145.34 ± 113.25 (53)	1.47 ± 1.11 (11)	2.22 ± 1.37 (48)	58.10
11.	*I. puella*	1.92 ± 1.08 (16)	243.35 ± 187.08 (23)	1.66 ± 1.24 (11)	1.09 ± 0.79 (22)	14.09
12.	*O. oriolus*	1.92 ± 0.90 (12)	157.93 ± 78.20 (15)	1.58 ± 1.32 (11)	1.29 ± 0.86 (14)	10.30

TABLE 25. **Group size, Visitation length, Visitation rate, Feeding rate and Fruit removal rate of important avian frugivores at *F. microcarpa* (Vythiri Site)** (Figures are means with SD. Data in parentheses are sample sizes)

Sl. No.	Bird species	Group size	Visitation length	Visitation rate	Feeding rate	Fruit removal rate
1.	*T. pompadora*	4.92 ± 2.02 (9)	405.53 ± 226.60 (19)	0.84 ± 0.89 (9)	2.78 ± 1.37 (20)	77.65
2.	*M. virdis*	6.38 ± 4.15 (16)	240.86 ± 163.04 (28)	2.62 ± 1.51 (9)	2.48 ± 1.40 (26)	166.41
3.	*M. rubricapilla*	6.91 ± 4.56 (22)	209.08 ± 135.57 (17)	2.97 ± 1.85 (9)	2.15 ± 1.18 (15)	153.76
4.	*T. merula*	1.83 ± 1.17 (6)	401.80 ± 190.28 (15)	0.60 ± 0.78 (9)	1.57 ± 0.86 (15)	11.54
5.	*H. madagascariensis*	7.08 ± 2.84 (12)	126.62 ± 110.72 (21)	2.85 ± 2.17 (9)	1.81 ± 1.14 (22)	77.07
6.	*P. jocosus*	5.13 ± 2.72 (17)	135.38 ± 93.73 (16)	2.22 ± 2.08 (9)	1.96 ± 1.19 (16)	53.06
7.	*H. indicus*	2.11 ± 1.05 (9)	147.23 ± 88.16 (13)	0.71 ± 0.77 (9)	1.24 ± 0.78 (11)	4.56
8.	*I. puella*	1.14 ± 0.38 (7)	151.00 ± 109.20 (13)	0.45 ± 0.69 (9)	1.41 ± 0.77 (13)	1.82
9.	*G. religiosa*	3.75 ± 1.58 (9)	151.73 ± 93.91 (15)	0.54 ± 0.59 (9)	1.96 ± 1.46 (13)	10.04

TABLE 26. **Group size, Visitation length, Visitation rate, Feeding rate and Fruit Removal Rate of important avian frugivores at *F. tsjahela* (Vythiri Site).** (Figures are means with standard deviations. Sample sizes in parentheses)

Sl. No.	Bird species	Group size	Visitation length	Visitation rate	Feeding rate	Fruit removal rate
1.	*T. pompadora*	6.75 ± 4.36 (8)	410.71 ± 271.27 (16)	0.80 ± 0.98 (10)	3.01 ± 1.69 (16)	111.26
2.	*M. virdis*	5 ± 4.26 (15)	281.53 ± 159.71 (17)	2.38 ± 1.52 (10)	2.96 ± 1.36 (17)	165.27
3.	*M. rubricapilla*	6.92 ± 5.72 (12)	209.26 ± 118.28 (11)	2.50 ± 1.63 (10)	2.96 ± 1.29 (27)	178.60
4.	*H. madagascariensis*	4.89 ± 2.47 (10)	152.19 ± 70.97 (22)	1.60 ± 1.43 (10)	1.51 ± 1.18 (22)	29.27
5.	*H. indicus*	2.25 ± 1.28 (9)	192.79 ± 167.80 (19)	0.60 ± 0.64 (10)	1.41 ± 1.21 (17)	6.12
6.	*G. religiosa*	4.86 ± 2.12 (10)	176.79 ± 61.43 (14)	0.57 ± 0.66 (10)	1.52 ± 1.18 (14)	12.41
7.	*O. oriolus*	1.5 ± 0.58 (7)	152 ± 51.66 (11)	0.39 ± 0.45 (10)	1.81 ± 1.62 (11)	0.63
8.	*Z. palpebrosa*	7 ± 4.15 (6)	157.62 ± 95.31 (13)	0.85 ± 0.92 (10)	1.11 ± 0.75 (13)	17.35

frequency (0.65 $\pm$ 0.86 visits/hr.). The Redwhiskered Bulbul, Hill Myna, Blue Bird, Golden Oriole etc. had moderate visitation rates (Table 24).

Observation on the visitation paterns of nine 'important' bird species utilising the fig crop of F. microcarpa were carried out. Table 25 describes the differential visitation frequencies of these bird species. The Small Green Barbet, Crimson-throated Barbet and Black Bulbul had similar visitation patterns (Table 25, $P > 0.30$ Mann-Whitney U test). Each had significantly greater visitation frequency than Green Pigeon (M-W- U test $P < 0.05$). The Black Bird, Hill Myna and Yellowbrowed Bulbul had mean frequencies of visits 0.60, 0.54 and 0.71 respectively. The Redwhiskered Bulbul made an average 2.22 visits in an hour at F. microcarpa . The lowest visitation rate among the nine bird species studied was found in the Blue Bird, ($\bar{x}$ 0.45 $\pm$ visits/hour) which is an opportunistic fruit-eater (Table 25).

At Ficus tsjahela the differential visitation rates of eight avian frugivores were estimated (Table 26). The Small Green Barbet and Crimson-throated Barbet 6 to 7 visits/hour were the most frequenting species. The Greyfronted Green Pigeon was seen to be less interested in these small sized figs (7.4 mm). It had a mean visitation rate of 0.80 visits/hour. The barbets had significantly greater visitation rate than the pigeons ($P < 0.02$ Mann-Whitney U test).

The Black Bulbul frequented this fig at averages 1.60 visits per hour. The White Eye foraged average 0.85 times in an hour of observation. The Hill Myna, Yellowbrowed Bulbul and Golden Oriole were rather less frequent visitors (Table 26).

Feeding Bout

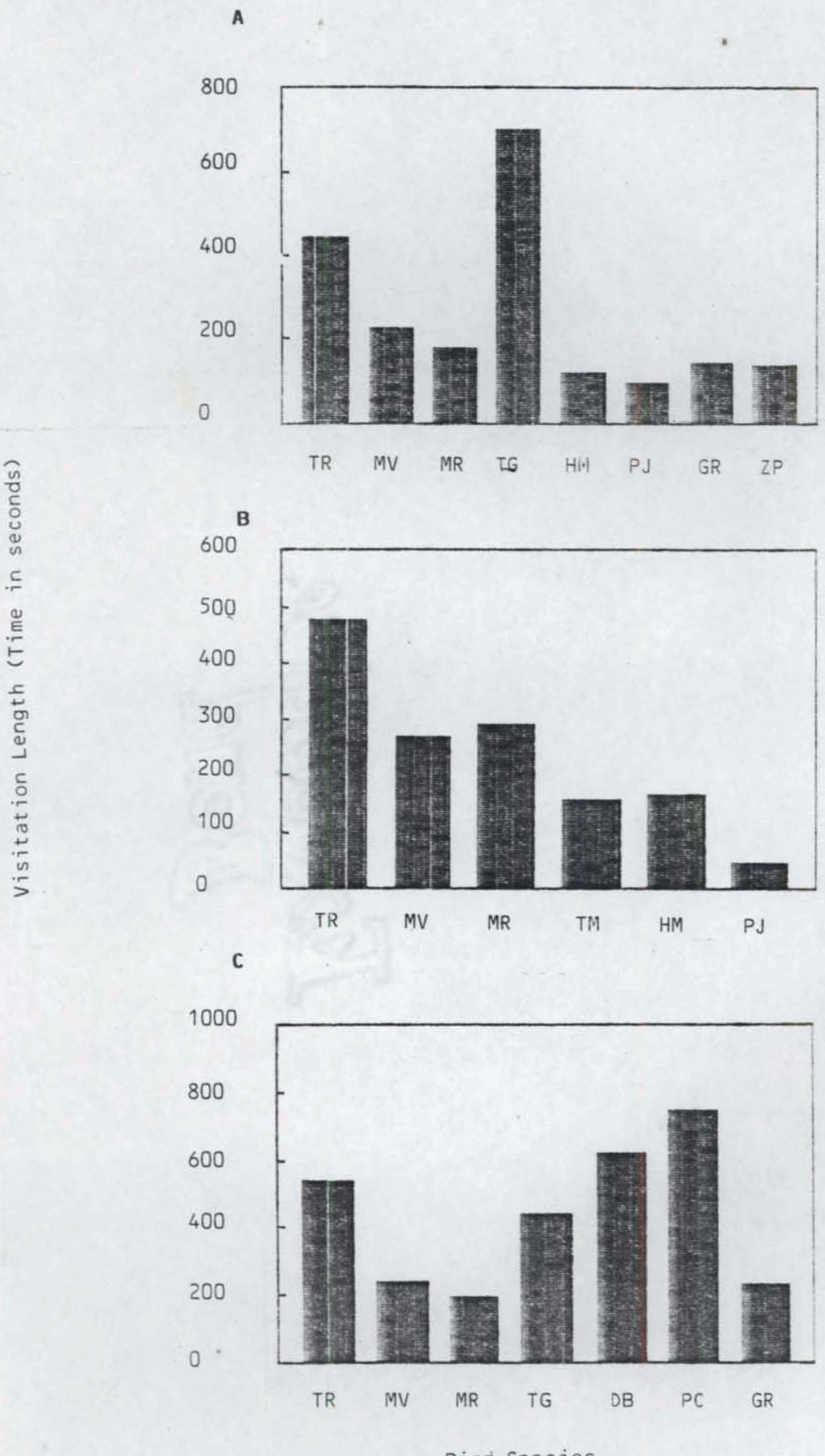
The mean time spent per visit by nine avian fig-eaters of F. exasperata were recorded in this study (Table 21). The length of feeding bouts of various bird species varied considerably. The hornbill (T. griseus) with mean visitation length of 701.92 seconds had significantly longer feeding visits than the Green pigeon ($U = 67.5$, $P < 0.03$). It differed significantly from other important frugivores also ($P < 0.001$, Mann-Whitney U test). The Greyfronted Green Pigeon foraged for ten to thirteen minutes. It also differed significantly from barbets ($P < .001$). The Small Green Barbet and Crimsonthroated Barbet performed several shorter feeding visits ($\bar{x}$ 228.24 sec $\pm$ 99.63 SD., $\bar{x}$ 177.17 sec $\pm$ 110.53 SD respectively). The specialists Black Bulbul and opportunists like Hill Myna, Blue Bird and White-eye had similar but much shorter feeding bouts (Table 21). The Redwhiskered Bulbul ($\bar{x}$ 97.17 sec $\pm$ 93.64 SD) had the shortest feeding bout among the nine bird species studied (Fig. 12a).

The Hornbill, Green Pigeon and Small Green Barbet were the most successful foragers having over 90% success rate. The Crimsonthroated Barbet and Hill Myna were also highly successful at eating F. exasperata figs (86.67%, 80% success rates respectively). The Black Bulbul, Redwhiskered bulbul and White Eye had nearly 70% success rate each (Fig. 14a).

At F. nervosa the respective visitation lenghts (Fig. 12b) and sucess rates of six bird species were accounted (Fig. 14c). The Green Pigeon (T. pompadora) having spent a mean time of 472. 89 seconds had the longest feeding bout. If differed significantly from others ($P < 0.02$, table 22). The Small Green Barbet and Crimsonthroated Barbet foraged for similar span of time per visit ($\bar{x}$ 266.96 sec $\pm$ 180.90 SD; $\bar{x}$ 290 sec $\pm$ 165.87 SD respectively). The Black Bird, Black Bulbul and Redwhiskered Bulbul spent almost similar length of time per visit (Table 22; $P < 0.50$).

The six species had varied rates of success at F. nervosa fruiting crown (Fig. 14c; Table 27). The Green Pigeon and the Small Green Barbet had cent percent successful bouts while the Crimsonthroated Barbet achieved 97% sucess. The Black birds were also highly successful (88.89%). The Black Bulbul and Red whiskered Bulbul were relatively less efficient at F. nervosa and had much lower sucess rates (Fig. 14c).

Fig. 12. Visitation lengths of various avian frugivores attending *F. exasperata*, *F. nervosa* and *F. beddomei* in the Vythiri study area.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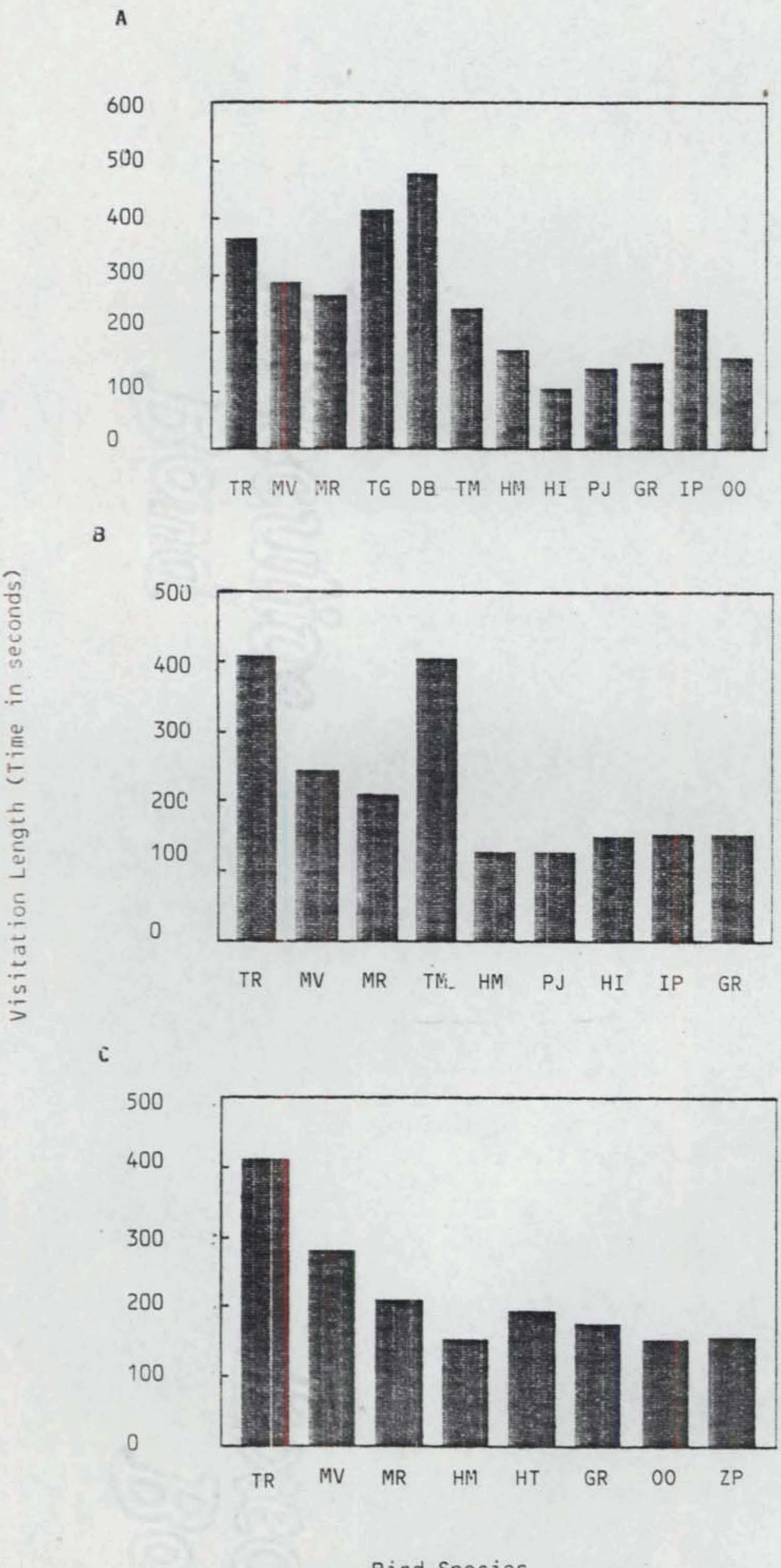
TR MV MR TG DB PC GR
Visitation Length (Time in seconds)
Bird Species

Table 23 describes the relative lengths of feeding bout of seven frugivores exploiting *F. beddomei* crop. The Bluewinged Parakeet which foraged for 25 to 30 minutes per visit had the longest feeding bout (Fig. 12c). The mean visitation lengths of Green Pigeon and Imperial Pigeon were 537.16 seconds and 621.55 seconds respectively. All the three frugivores had significantly greater visitation length than other bird species studied ($P < 0.05$ Table 23) except Hornbill. The Hornbill, had relatively shorter feeding bouts ($\bar{x}$ 439.06 sec $\pm$ 207.52 SD). The Hill Myna had a mean visitation length of 230 seconds.

The figs of *F. beddomei* were relatively large sized ($\bar{x}$ 23.94 $\pm$ 5.54 mm diameter). Majority of the aivan frugivores ate them bit-by-bit. The fully ripe figs were often easily detached and fallen to the ground. The success rates of different bird species varied considerably (Fig. 14b). The Hornbill and Imperial Pigeon had over 90% success rate and were the most successful species. The Greyfronted Green Pigeon and Blue-winged Parakeet also had higher and similar success rates (86.67%, 81.82% respectively). The Small Green Barbet and Crimsonthroated Barbet were slightly less successful in manipulating this fig crop. (75.44%, 73.08% respectively). The Hill Myna was the least successful (63.64%) species.

The differential visitation lengths of twelve important

Fig. 13. Visitation lengths of various avian frugivores attending _F. amplissima_, _F. microcarpa_ and _F. tsjahela_ in the Vythiri study area.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TR MV MR HM HT GR OO ZP
Visitation Length (Time in seconds)
Bird Species

frugivores foraging on *F. amplissima* were recorded (Table 24, Fig. 13a). The Imperial Pigeon spent much greater span of time per visit than other birds (Table 24). It had significantly longer feeding visit than Green Pigeon and barbets (P < 0.05 Mann-Whitney U test). The Greyfronted Green Pigeon foraged for average 363.89 seconds. The Small Green Barbet and Crimsonthroated Barbet had visitation lengths averaging 287.90 seconds and 263.67 seconds respectively. The Black Bird and Blue Bird had similar and slightly shorter feeding bouts (Fig. 13a). The specialists such as Black Bulbul, Redwhiskered Bulbul and Yellowbrowed Bulbul had visitation lengths similar to that of Hill Myna and Golden Oriole (Fig. 13a).

The success rates varied considerably among the twelve bird species studied (Fig. 15a; Table 27). The Green Pigeon, Small Green Barbet, Coppersmith Barbet and Imperial Pigeon scored about 95% success. The Black Bird, Blue Bird, Redwhistered Bulbul and Golden Oriole also achieved remarkably high success rate (> 85%). Eighty percent of the feeding bouts ended successfully in Malabar Grey Hornbill. The Yellowbrowed Bulbul with a success rate of 76.47% was the least successful of the twelve species studied (Fig. 15a).

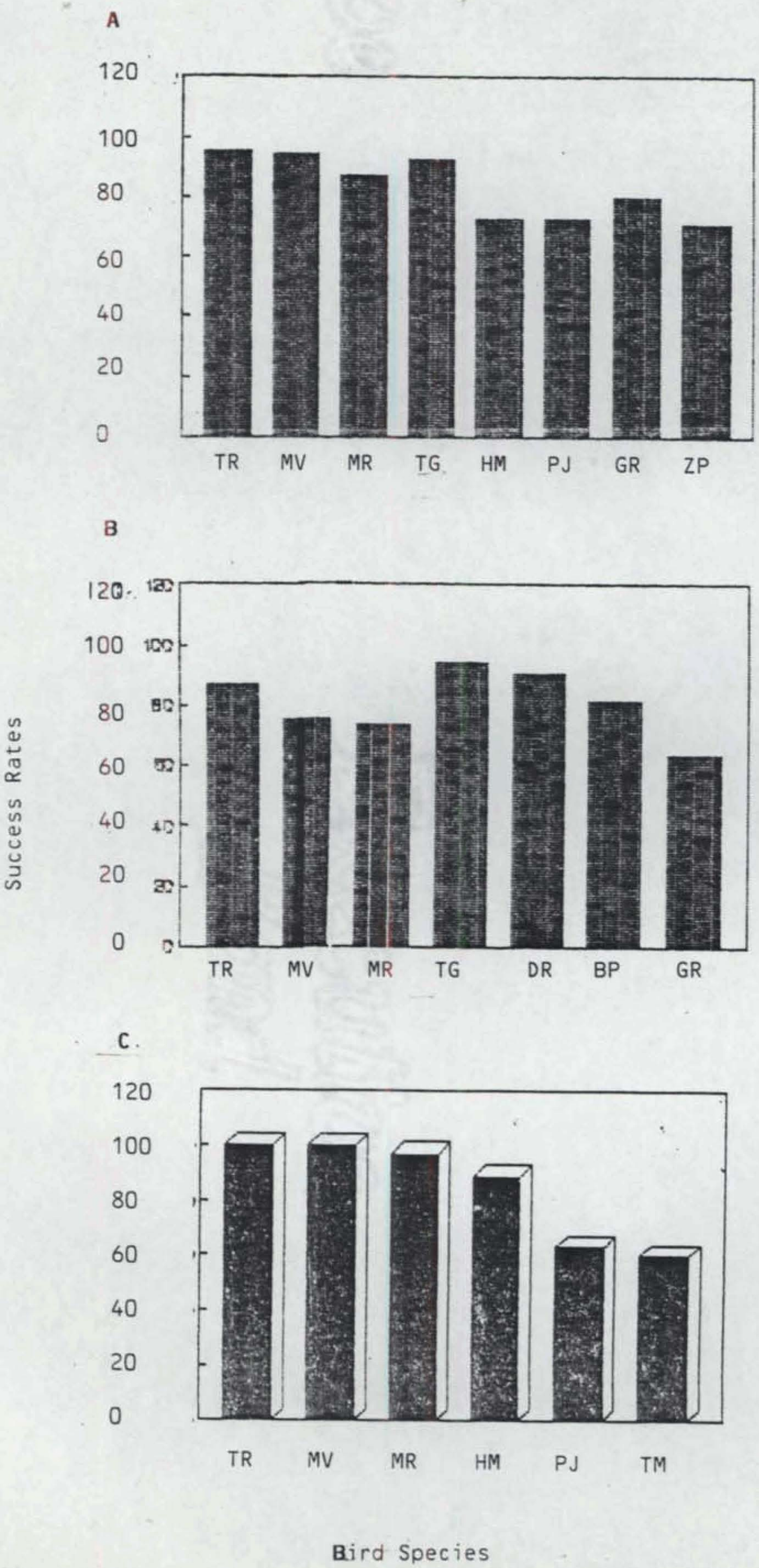
Table 25 and figure 13b describe the varying length of feeding visits of nine species of birds on *F. microcarpa*. The Greyfronted Green Pigeon and Black Bird (*T. merula*) with mean bout lengths of 405.53 seconds and 401.80 seconds respectively had significantly

TABLE 27. **Relative success rates of foraging of various avian frugivores at various fruiting *Ficus* spp. in the Vythiri Site**

(Figures are percentages of successful bouts. Blank spaces represent either absence of bird species or considered as insignificant)

Sl. No.	Bird species	*F. tsjahela*	*F. microcarpa*	*F. amplissima*	*F. exasperata*	*F. nervosa*	*F. beddomei*
1.	Greyfronted Green Pigeon	88.23	90	95.65	94.74	100	86.67
2.	Small Green Barbet	94.11	95.83	96.42	93.75	100	75.44
3.	Crimsonthroated Barbet	92.86	96	94.03	86.67	97.05	73.08
4.	Malabar Grey Hornbill	--	--	80.00	92.30	--	93.75
5.	Imperial Pigeon	--	--	93.33	--	--	90.91
6.	Bluewinged Parakeet	--	--	--	--	--	81.82
7.	Black Bulbul	81.82	81.87	77.27	72.73	60	--
8.	Yellowbrowed Bulbul	77.78	70	76.47	--	--	--
9.	Redwhiskered Bulbul	--	92.85	88.24	72.50	63.64	--
10.	Black Bird	--	86.67	86.67	--	88.89	--
11.	Blue Bird	76.92	92.31	85.00	--	--	--
12.	Hill Myna	78.57	76.92	85.71	80	--	63.64
13.	Golden Oriole	81.82	--	86.67	--	--	--
14.	White-eye	84.62	71.43	--	70.83	--	--

Fig. 14. Percent successful bouts of different bird species at (a) _F. exasperata_ (b) _F. beddomei_ (c) _F. nervosa_ (Vythiri site). Avian codes used as in table 6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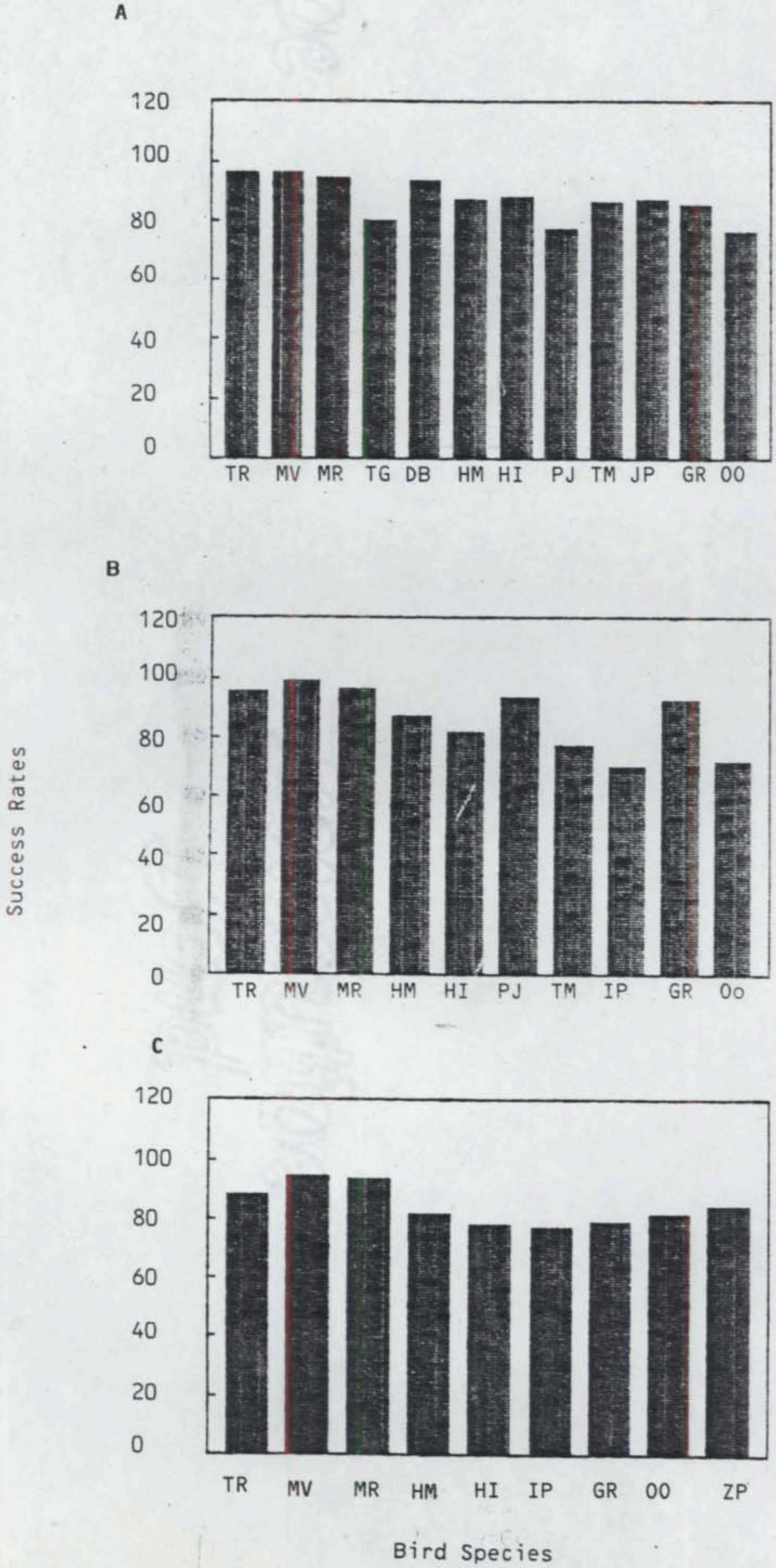
Success Rates
Bird Species

longer feeding visits than other foragers (P < 0.02, Mann-Whitney U test). The Samll Green Barbet and Crimsonthroated Barbet had similar and shorter feeding bouts ($\bar{x}$ 240.86 sec ± 163.04 SD, $\bar{x}$ 209.08 sec ± 135.57 SD respectively). The feeding bouts of Black Bulbul, Hill Myna and Blue Bird lasted three to five minutes. They had similar visitation patterns. There was significant difference between specialists and opportunists in their lengths of feeding bout.

The relative success rates of feeding attempts of nine frugivores at F. microcarpa are as shown in the Fig. 15b and Table 27. The Small Green Barbet, Crimsonthroated Barbet, Blue Bird and Redwhiskered Bulbul achieved 92 to 96% success rates while the Green Pigeon could attain a success rate of 90%. The Black Bird and Black Bulbul had around 80% of their feeding visits ended successfully. The Hill Myna and the Yellowbrowed Bulbul were the least succssful species studied (Fig. 15b).

At F. tsjahela the visitation lengths of eight bird species were estimated (Table 26; Fig. 13c). The Green Pigeon foraged for ten fifteen minutes per visit. It had significantly greater lengths of visit than other avian visitors (P < 0.05). The Small Green Barbet and Crimsonthroated Barbet had mean visitation lengths of 281.53 seconds and 209.26 seconds respectively. The Yellow-browed Bulbul spent an average 192.79 seconds per visit. The Hill Myna, Golden

Fig. 15. Percent successful bouts of different bird species at (a) *F. amplissima* (b) *F. microcarpa* (c) *F. tsjahela* (Vythiri Site)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Success Rates
Bird Species

Oriole, Black Bulbul, and White Eye made relatively shorter feeding visits and all had more or less similar visitation pattern (Table 26).

The number of successful feeding bouts and the relative feeding efficiency varied considerably (Fig. 15c). The Small Green Barbet and Crimsonthroatad Barbet were the most successful species (94.11%, 92.86% respectively). The Greyfronted Green Pigeon was slightly less successful (88.23%). The Golden Oriole and Black Bulbul had almost equal success rates (Fig. 15c). The Hill Myna, Blue Bird, and Yellowbrowed Bulbul had similar rates of success (table 27).

Feeding Rate

The relative feeding rates were determined for nine frugivore species attending F. exasperata fruiting crown (Table 21). The Hornbill was the fastest fig eater at this species. It had significantly greater feeding rate than fruit pigeons and barbets ($P < 0.001$). The Greyfronted Green Pigeon and Small Green Barbet ate figs at mean rates of 0.31 ± 0.15 and 0.57 ± 0.76 figs /minute respectively. The Small Green Barbet was significantly faster than the Crimsonthroated Barbet ($U = 405$, $P < 0.001$). The Crimsonthroated Barbet and Hill Myna were slightly slow foraging species ($\bar{x}$ 0.21 ± 0.15; $\bar{x}$ 0.20 ± 0.15 figs/minute respectively). The Blue Bird, Black

Plate 14. a. Small Green Barbet attempting to pluck the fig of F. exasperata

b. A male koel attempting to swallow the fig.

PLATE 14

a

b

Bulbul, Redwhiskered Bulbul and White Eye were rather slow consumers and had almost similar feeding rates (Table 21).

At F. nervosa the mean feeding rates of Six bird species were estimated (Table 22). The Small Green Barbet eating an average 1.08 figs per minute was the quickest at this fig. It ate significantly faster than the Green Pigeon and the Crimson-throated Barbet ($P < 0.002$, 2-tailed Mann -Whitney U test). The Fruit Pigeon consumed a mean 0.62 figs per minute while the Crimsonthroated Barbet devoured average 0.40 figs per minute. The mean consumption rate of Black Bird was 0.51 figs while the Black Bulbul and Redwhiskered Bulbul were handling these figs very slowly ($\bar{x}$ 0.08 $\pm$ 0.09 and $\bar{x}$ 0.12 $\pm$ 0.12 figs per minute respectively).

Table 23 describes the differential consumption rates of six species of bird studied on F. beddomei fig crown. The Hornbill with its large bill and wide gape could successfully pluck and swallowed these large figs whole. They consumed five to seven figs per bcut and bad much larger feeding rate than all other avian foragers (Table 23). The Greyfronted Green Pigeon and the Small Green Barbet ate $\bar{x}$ 0.17 $\pm$ 0.13 and $\bar{x}$ 0.18 $\pm$ 0.15 figs per minute respectively. The Crimsonthroated Barbet, and Hill Myna and Black Bird had much lower and similar rates of feeding (Table 23).

The medium sized figs (10.60 ± 1.8 mm) of *F. amplissima* were found to be easily taken whole by majority of avian visitors. In the present study the relative feeding rates of twelve important bird species were estimated (Table 24). The Hornbill which consumed up to forty figs in a visit had the greatest feeding rate. It differed significantly from Green Pigeon and Crimson throated Barbet ($P < 0.02$). The Imperial Pigeon, Green pigeon and Small Green Barbet were quite fast feeding and had similar rates ($P > 0.30$). The Crimsonthroated Barbet and Hill Myna ate average 1.94 and 2.2 figs per minute respectively. The Black Bird and Golden Oriole each consumed an average 1.30 and 1.29 figs per minute respectively. The Black Bulbul and Blue Bird were slightly slow fig consumers (Table 24).

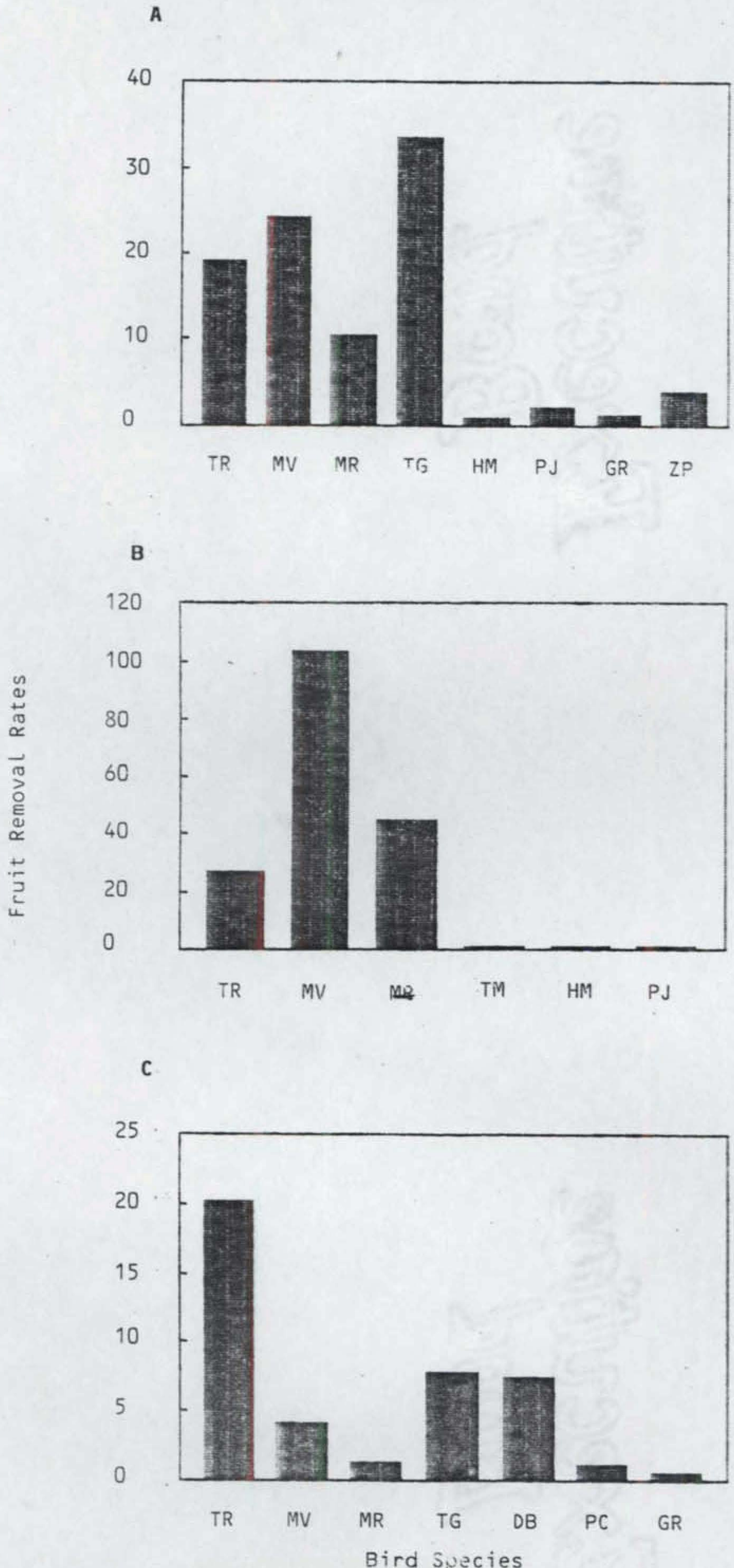
The Greyfronted Green Pigeon and the Small Green Barbet eating up to twenty five figs per bout ($\bar{x}$ 2.78 ± 1.37; $\bar{x}$ 2.48 ± 1.40 figs/minute respectively) were much quicker among the nine species of birds studied on *F. microcarpa*. The Crimson-throated Barbet also had relatively high feeding rate at this fig ($\bar{x}$ 2.15 ± 1.18 figs/minute). The Hill Myna and the Redwhiskered Bulbul ate the figs at almost equal rate (Table 25). The Black Bulbul, Blue Bird and Black Bird ate average 1.81, 1.51 and 1.41 figs per minute respectively. The yellow-browed Bulbul was the slowest of nine species observed ($\bar{x}$ 1.24 ± 0.78 figs/minute).

Table 26 shows the feeding rates of eight species of birds exploiting the crop of _F. tsjahela_. The three frugivore specialists namely, the Green Pigeon, the Small Green Barbet and the Crimson-throated Barbet had similar rates of consumption. They were significantly faster than other avian consumers studied here (Table 26, $P < 0.05$). The Golden oriole consumed about figs per minute and was the fastest opportunistic visitor at _F. tsjahela_. The Black Bulbul, Yellowrowed Bulbul and Hill Myna had similar rates of feeding (Table 26). The White eye successfully handled an average 1.11 figs per minute while the Blue Bird consumed only an average 0.97 figs per minute. It has the least feeding rate among the eight bird species studied (Table 26).

Fruit Removal Rate

The mean number of figs removed by each of the nine species of frugivores in an hour of observation at _Ficus exasperata_ were calculated (Table 21, Fig. 16a). The Hornbill (_T.griseus_) accounted for 35.34% of total figs removed by various bird species. it removed significantly greater number of figs than the Greyfronted Green Pigeon ($x^2 = 4.10$ $P < 0.05$). The latter removed an estimated 19.70% of figs in an hour. The Small Green Barbet (25.12%) removed a slightly larger number of figs than the Green Pigeon and significantly larger number of figs than its congener, the Crimson

Fig. 16. Fruit removal rates of important avian frugivores on *F. exasperata*, *F. nervosa* and *F. beddomei*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Fruit Removal Rates
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TR
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Bird Species

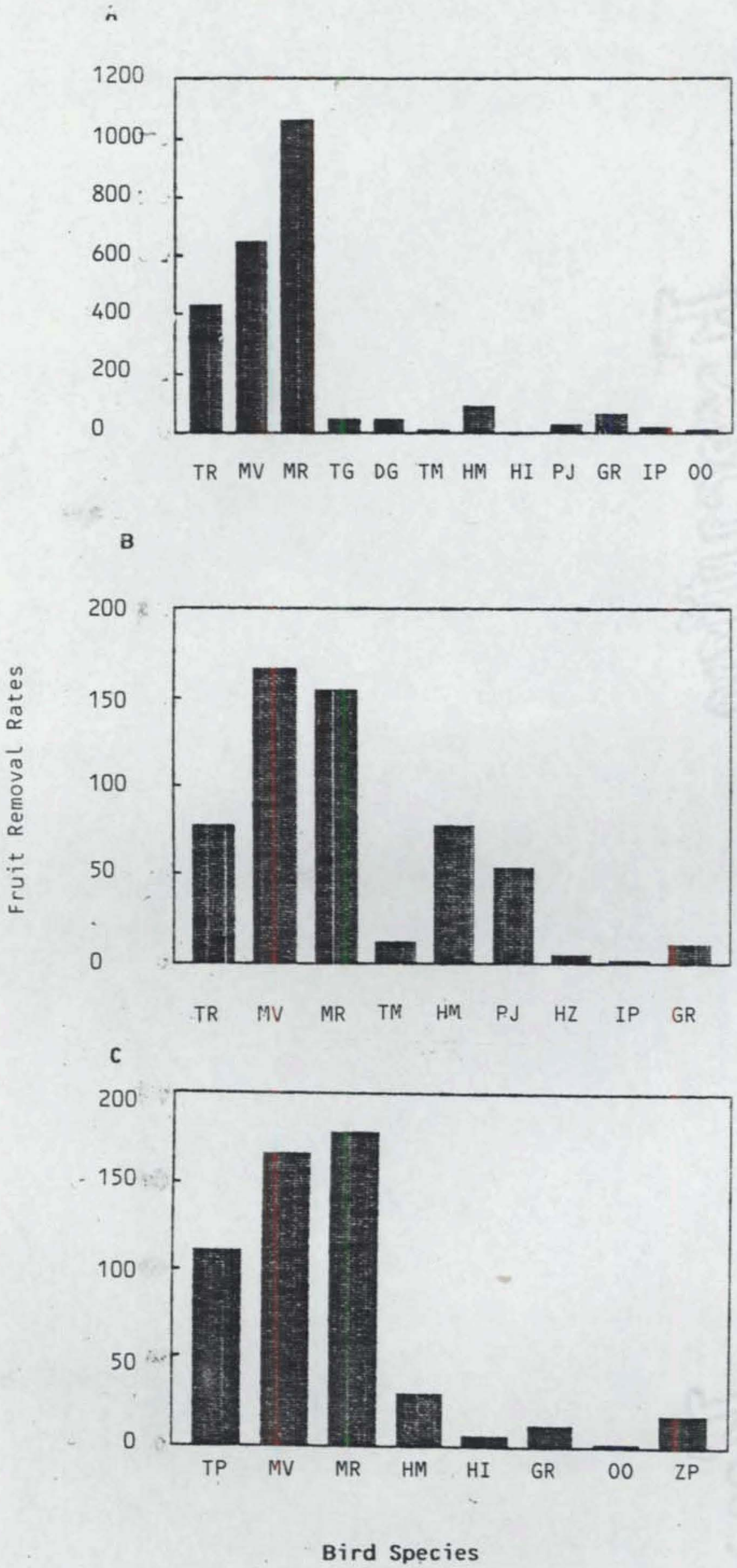
throated Barbet (11.08%, $x^2 = 5.65$, $P < 0.02$). The Redwhiskered and Black Bulbuls, Fair Blue Bird, White Eye etc. had much lower removal rate (Table 21). These four species together accounted for the removal of less than 10% of figs in an hour of observation.

The fig removal rate of each of the six species of birds attending to _F. nervosa_ crop is estimated and is given in Table 22. The Small Green Barbet harvested 103 of 147 figs (70.39%) consumed by the guild of six different bird species during this study. It had much greater removal rate than the Green Pigeon (18.15%) and the Crimsonthroated Barbet (10.28%) . The Black Bird, Redwhiskered and Black bulbuls could remove only a lower number of figs (Fig. 16b).

AT _F. beddomei_, the Green Pigeon removed the highest proportion of total figs among the seven bird species studied (Table 23). The Malabar Grey Hornbill and the Imperial Pigeon, despite their lower visitation rate and smaller group sizes had greater fruit removal rate than more frequently visiting barbets in this study (Fig. 16c). The Groups of Small Green barbet consisting of 7 to 8 birds harvested an average 4.02 figs per hour of observation while Crimsonthroated Barbet, Bluewinged Parakeet and Hill Myna could handle only a fewer number of figs per hour (Fig. 16c).

At the fruiting crown of _F. amplissima_ almost 90% of figs removed in an hour were handled by the three specialists such as the

Fig. 17. Fruit removal rates of important avian frugivores on *F. amplissima*, *F. microcarpa* and *F. tsiahela*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TR MV MR TM HM PJ HZ IP GR
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TP MV MR HM HI GR OO ZP
Fruit Removal Rates
Bird Species

Greyfronted Green Pigeon, the Small Green Barbet and the Crimson-throated Barbet (Table 24, Fig. 17a). However, the flock of Crimsonthroated Barbet ($\overline{x}$ 21.48 birds) had the highest removal rate (1062.12 figs) and it differed significantly from Green Pigeon and Small Green Barbet (x^2 = 14.92, df = 2, P < 0.05). The Small Green Barbet consumed about 645 figs per hour while Green Pigeon manipulated about 431.77 figs. The removal rates of Hornbill, Imperial Pigeon and Black Bulbul were estimated to be 40.87, 39.37, and 92.62 figs per hour respectively. The Redwhiskered Bulbul which removed an average 22.72 figs per hour had significantly lower rate of removal than the Black Bulbul (x^2 = 42.36, P < 0.001). The Black Bird removed only 7.06 figs per hour. The opportunists Hill Myna with an average group size of 7.35 birds handled 58.10 figs in an hour of observation. The Blue Bird and Golden Oriole had much lower removal rates (14.09 and 10.30 figs per hour respectively). The fruit eating specialists, Yellow-browed Bulbul had the lowest removal rate of the twelve species studied (Table 24).

At F. microcarpa, the nine avian species studied together accounted for the removal of about 400 figs in an hour of observation (Table 25, Fig. 17b). The Small Green Barbet and the Crimsonthroated Barbet removed maximum number of figs (41.66% and 38.49% respectively). They ate significantly greater proportion of figs than the Green Pigeon (x^2 = 8.08, P < 0.01; x^2 6.26, P< 0.02

respectively). The Green Pigeon and Black Bulbul had almost equal removal rates (Fig. 17b). The Redwhiskered Bulbul had a moderate rate of removal (12.60%). The opportunists, Blue Bird and Hill Myna and the specialist Black Bird had rather low rate of removal (Fig. 17b).

At *F. tsjahela* the differential fruit removal rates of eight different species of birds were accounted (Table 26, Fig. 17c). The Small Green Barbet and the Crimsonthroated Barbet removed an average 165.27 and 178.60 figs respectively. The Greyfronted Green Pigeon removed only 111.26 figs per hour. These three specialists were responsible for 8.82% of figs removed. The Black Bulbul and White Eye harvested about 30 and 17 figs respectively while the Yellowbrowed Bulbul, Hill Myna and Golden Oriole each removed average 6.12, 12.41 and 0.63 figs per hour respectively.

TIME BUDGET

T. N. Vijayakumar "Resource utilization by birds attending figs in South India"
Thesis. Department of Life Sciences , University of Calicut, 1994

CHAPTER 5

TIME BUDGET

Site I

Individual time budgets were studied in the populations of various important frugivores in the present investigation. Allocations of time for various behavioural activities of nine frugivore species were monitored in the Tenhipalam site (Table 28). All data were collected from observations on F. benghalensis. The behavioural repertoire of a bird species was categorised into seven major types such as foraging (including searching and feeding), resting (Perching), preening, flight or locomotion (Other than for foraging and chasing), chase or agonistic, courting and cleaning the bill. The time for which the focal bird remained hidden or masked by the foliage was also recorded. The time spent in each activity was expressed as percentage of total time of that observation. The proportion of time devoted to different behavioural categories were variable in most species (Table 28). There was significant variation in the time taken for different activities by a species ($P > 0.001$, One-way ANOVA Table 28a).

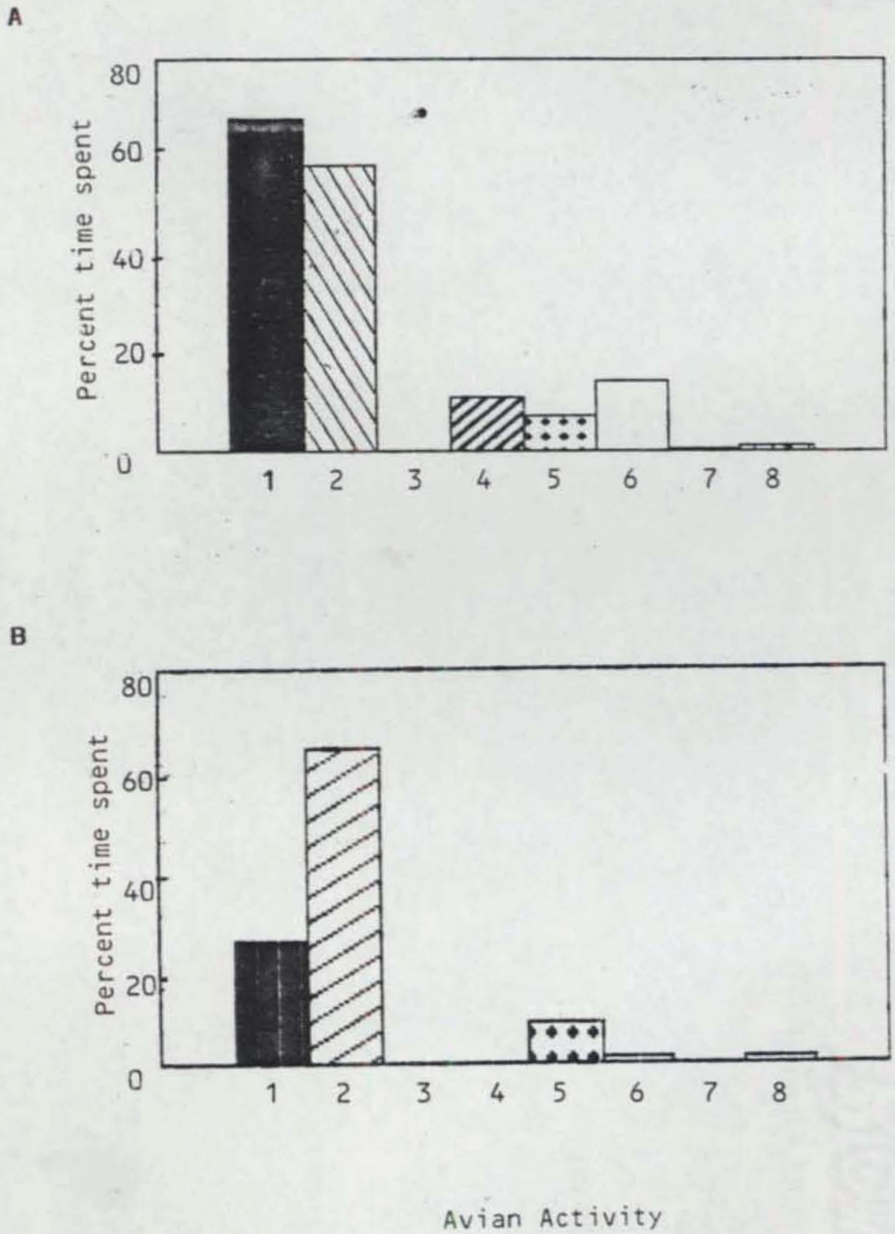
TABLE 28. **Time spent in various activities during foraging by important bird species in the Tenhipalam Study area**
(Data represent mean percentages with standard deviation. N = Sample size)

Bird spp.	Perching	Foraging	Flight	Chasing	Oos*	Preening	Courtesy	Cleaning	N
E. scolopacea	42.26±20.56	36.33±21.72	0.05±0.20	6.86±9.55	4.36±9.55	8.88±13.84	0.13±0.36	0.73±0.78	77
M. virdis	28.83±17.35	54.66±17.57	1.47±1.67	1.45±1.09	7.32±10.83	5.04±11.38	0.07±0.34	1.06±0.96	50
M. haemacephala	29.82±14.98	53.26±25.05	1.68±1.93	0.15±0.38	8.85±9.17	4.88±9.17	0.11±0.43	1.25±0.91	30
T. phoenicoptera	32.68±25.33	50.10±28.42	0.29±0.60	0.63±1.04	5.00±9.07	9.46±15.79	0.18±0.51	1.66±0.71	48
P. cyanocephala	25.26±26.86	64.11±32.24	0.15±0.30	0.07±0.26	8.07±15.96	1.22±4.76	- 0 -	1.12±0.92	26
C. macrorhynchos	36.0±20.01	52±23.94	1.74±1.73	1.56±1.83	2.26±5.73	6 .02±13.56	- 0 -	1.42±0.86	18
C. splendens	39.16±17.51	48.05±18.58	1.41±2.67	0.63±1.42	4.18±8.77	5.22±8.50	- 0 -	1.35±0.86	19
A. tristis	32.32±18.34	52.20±22.01	1.44±1.57	0.57±1.07	6.67±11.88	5.56±10.23	- 0 -	1.24±1.06	10
O.oriolus	19.25±15.75	63.51±17.96	0.97±1.14	0.17±0.56	8.56±12.45	6.14±15.89	0.20±0.94	1.20±0.96	46

*Oos - Out of sight.

Fig. 18. Percent time spent in activities by (A) Koel (B) Blossomheaded Parakeet

1. resting; 2. foraging; 3. locomotion;
4. agonistic; 5. Out-of-sight; 6. Preening;
7. Courting; 8. bill cleaning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Avian Activity

Foraging

In most species of birds except *E. scolopacea* greater proportion of time was alloted for foraging activities (Table 28, Fig. 18a). *E. scolopacea* spent slightly more time for resting ($\bar{X}$ 42.26%) than foraging ($\bar{X}$ 36.33%). The mean foraging time in the fruit pigeon *T. phoenicoptera*, (Fig. 19c), barbets *M. virdis* (Fig. 19a) and *M. haemacephala* (Fig 19b), the crow *C. macrorhynchos*, myna *A. tristis* were more or less equal, ranging from 50 to 55% of time (Fig 20 a & b). The parakeet *P. cyanocephala* and the Oriole *O. oriolus* each apportioned an average 60% of time for foraging acivity.

Resting and Preening

E. scolopacea rested ($\bar{X}$ 42.2%) and preened ($\bar{X}$ 8.88%) for nearly half of the total time. *T. phoenicoptera* has spent averages 32.68% and 9.46 % of time budget for resting and preening activities respectively. Both the Koel and Green Pigeon were usually found to perch on the same branch for greater part of the day. The barbet species *M. virdis* and *M. haemacephala* remained actively feeding for almost the entire length of bouts (Fig. 19a and b). They spent only one-third of the time budget for resting ($\bar{x}$ 28.83% and $\bar{x}$ 29.82% respectively) and preening ($\bar{x}$ 5.04%, $\bar{x}$ 4.88% respectively). The parakeet *P. cyanocephala* had allocated average 23.23% of time for

Fig. 19. Percent time spent in activities by

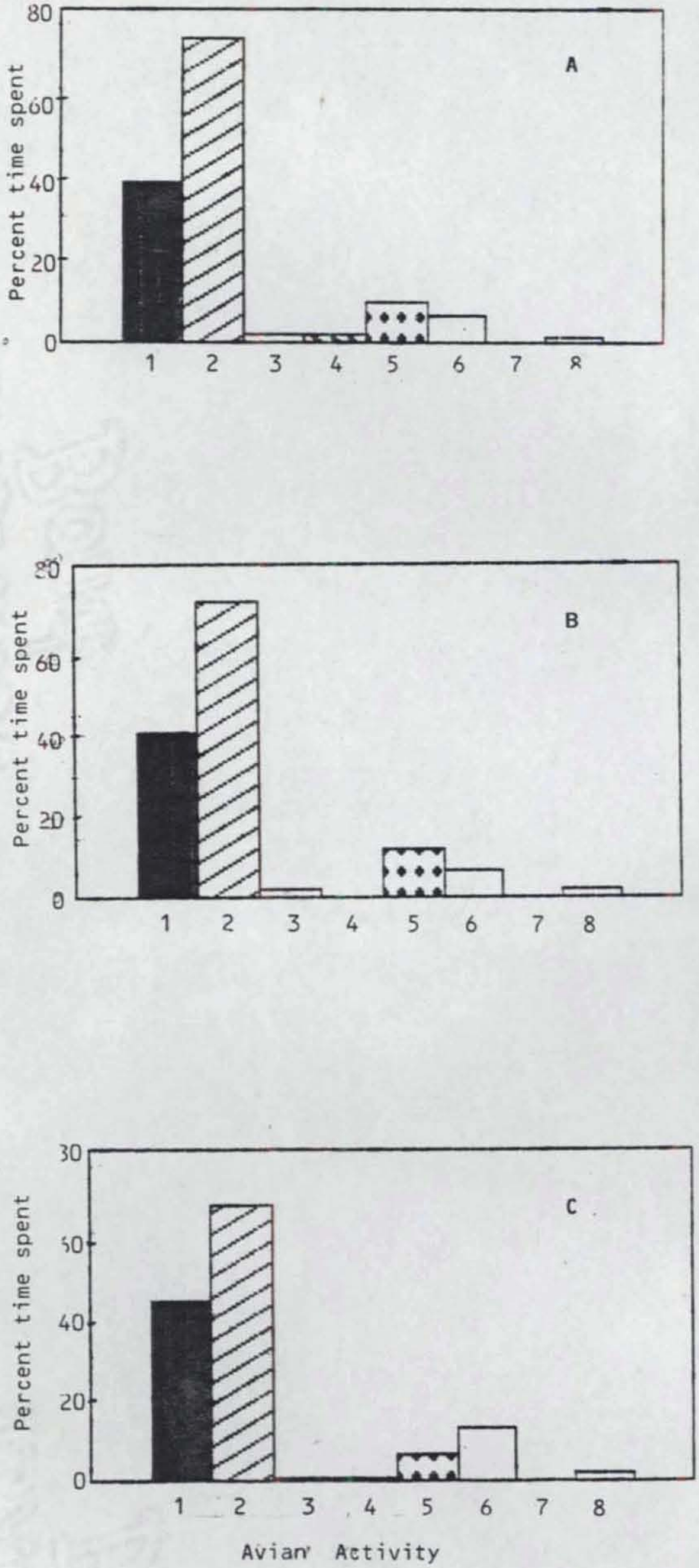
(A) Small Green Barbet; (B) Coppersmith Barbet

(C) Common Green Pigeon

1. resting; 2. foraging; 3. locomotion;

4. agonistic; 5. Out-of-sight; 6. Preening;

7. Courting; 8. bill cleaning


A
B
C
Percent time spent
Avian Activity

resting and only 1.27% of time for preening (Fig. 18 b) The crow C. macrorhynchos took rest for nearly half of the total time (Table 28 & Fig. 20 a). The myna A. tristis was at perch for a slightly lesser time ($\bar{x}$ 32%) than the crow while the oriole O. oriolus allocated only about one-fourth of the time budget for resting and preening purposes (Fig 20 c). The brief breaks during a bout by most bird species were, probably, for conserving energy for the next activity, though in Koel, it was more attentive to defending its feeding territory during interfeeding intervals.

Flight or Locomotion

The flight or locomotary activities included those other than for feeding or agonistic encounters. (For example, the movement for changing perch.) Birds such as crows were seen making distant flights either in semicircular, circular or straight path during the foraging episode. In smaller frugivores like barbets and orioles, these moves were often intended to changing perch site, particularly during interspecific or intraspecific interferences. However, the different species were found to spare only a very small fraction of total time for these miscellaneous movements (Table 28). The barbets spent nearly 2% of time budget for flights or locomotary activities. The Crow and Myna also allocated almost equal proportion of time as barbets for these locomotions. Unlike barbets, the latter two bird species had most of their non-foraging moves due to their frenetic

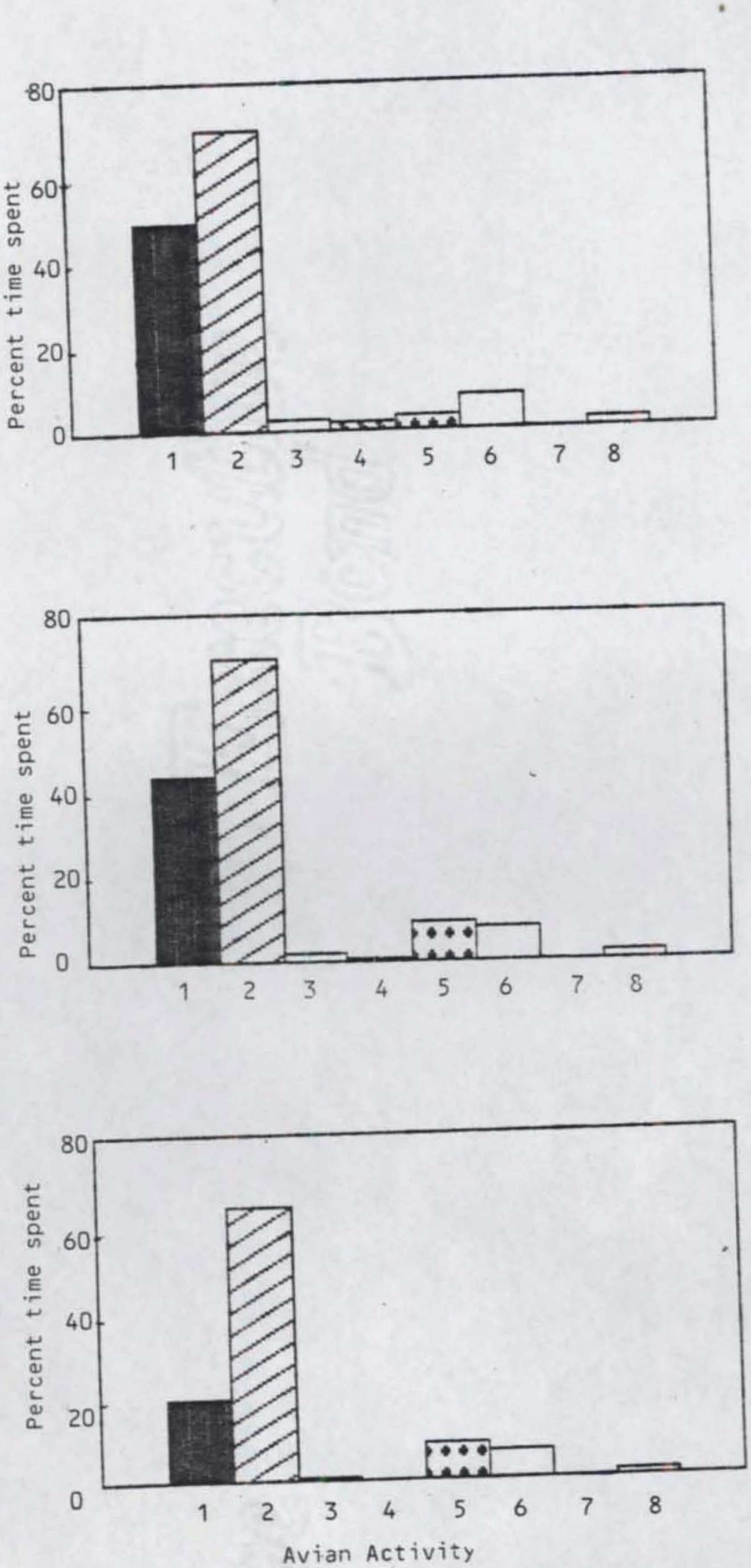
Fig. 20. Percent time spent in activities by
(A) Jungle Crow (B) Common Myna (C) Golden Oriole

1. resting; 2. foraging; 3. locomotion; 4. agonistic;
5. Out-of-sight; 6. preening; 7. courting; 8. Bill
cleaning

A

B

C



behaviour. All other species of birds studied alloted less than 1% of time for such locomotary purposes.

Agonistic

The intraspecific and interspecific competitions and aggressive encounters within the avian feeding flock were less intensive. However, the Koel was relatively more aggressive and this bird often supplanted or scared off all intruders either intraspecific or interspecific, from its feeding territory. The individuals of this species has allocated more time for agonistic interactions ($\bar{x}$ 6.86%). Other species of frugivores spent only a very small proportion of time in such competitive interactions. In them the agonistic interactions were mostly of intraspecific nature. The Jungle Crow was found to displace many smaller bird species from their feeding perch. Similarly the Common Green Pigeon, which also used to have rather feebly defended, foraging territories, made scaring attacks on intruders particularly the barbets. However, this species was less aggressive than the Koel and spent an average 0.63% of total time for agonistic ineractions. The Jungle Crow, the Small Green Barbet and the Common Myna have alloted average 1.56%, 1.45% and 0.57% of time budget respecively in this behavioural response. Other species of birds studied spared only a negligible amount of time for agonistic encounters (Table 28).

TABLE 28a. **Analysis of variance of percentage of time allocation for various activities by important fig-eating birds at Tenhipalam Site**

Bird species	DF	F-value	P
E. scolopacea	7	81.52	< 0.001
T. phoenicoptera	7	44.03	< 0.001
M. virdis	7	94.55	< 0.001
M. haemacephala	7	69.89	< 0.001
P. cyanocephala	7	44.96	< 0.001
C. macrorhyncos	7	49.16	< 0.001
C. splendens	7	38.72	< 0.001
A. tristis	7	26.24	< 0.001
O. oriolus	7	15.61	< 0.001

Courtship

In the present study very little courting activities were come across during feeding among the different avain frugivores. The courting displays, if any, often involved mutual chases between the paring individuals. Barbets, orioles and bulbuls were seen to make such courtship moves. No such courtship activity was observed in parakeets, crows and Common Myna in this study, while species such as the Green pigeon, Koel, Barbet, and Golden Oriole had spent a negligible portion of the time budget in courting gestures (Table 28).

Bill Cleaning

Scraps of figs often stuck to the beak surface of many bird species, particularly of those taking a piece-meal diet. The beak cleaning was usually done either by rubbing it with claws and toes or by wiping it against the perching branch. The frequency of bill cleaning varied considerably among various species. Each cleaning endeavour lasted 5 to 10 seconds in most bird species. The birds such as Crow, Myna, Oriole, Parakeet etc. which ate figs bit-by-bit spent relatively more time for bill cleaning than Koel and Small Green Barbet, which swallowed the figs following a brief mandibulation (Table 28).

Out-of-Sight

Usually, many of the feeding individuals were masked by fig foliage, eventhough for a few seconds. However, the actively foraging birds were more easily located than the perching individuals in these instances. The duration of time when the individual birds were out-of-sight of the observer varied from 2 to 10% of the time budget. The barbets and other smaller frugivores were easily got lost in the foliage. They were out-of-sight 5 to 20% of time. The cryptic green colouration of green pigeons, parakeets and barbets rendered observation of these species more difficult at *Ficus* crown. The pigeons were lost in view for 5% to 15% of time while the parakeets were out-of- sight for 5% to 25% of time.

The Golden Oriole and the Common Myna were hidden from view for average 8.56% and 6.67% time budget respectively. The Koel was a very shy and clumsy bird, which preferred to forage on the thickly foliated branches of fig. They remained out-of-sight for nearly an average 5% of total time.

Site II

In the Vythiri study area the analyses of time budgets of five important species of birds were carried out (Table 29 and Fig. 21 &

TABLE 29. **Time spent in activities during foraging by some important bird species at Vythiri study area**

Data represent mean percentage with standard deviation. N - sample size

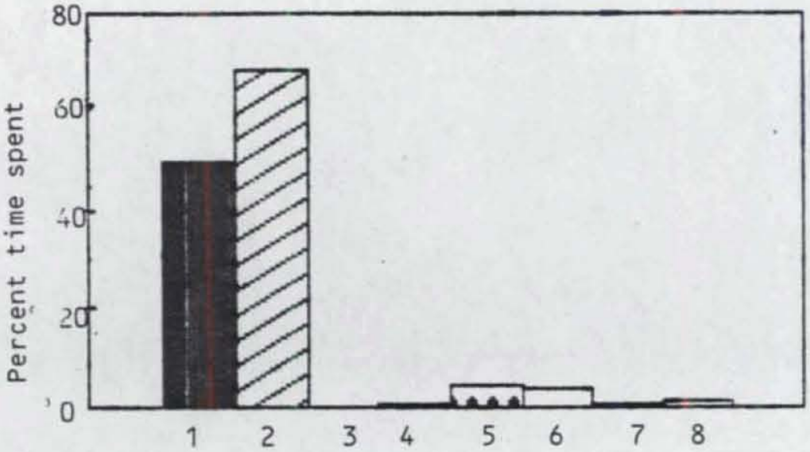
	Perching	Foraging	Flight	Chasing	Oos*	Preening	Courtesy	Cleaning	N
T. pompadora	37.32±19.77	51.38±18.35	0.27±0.54	0.47±0.63	3.30±5.18	3.10±7.82	0.37±0.87	0.93±0.67	21
M. virdis	13.20±11.79	72.09±15.05	1.00±1.14	0.89±1.91	7.44±11.72	4.01±8.36	0.52±1.36	0.76±0.97	18
M. rubricapilla	10.12±13.44	73.23±25.95	0.91±1.78	0.84±1.33	8.42±9.17	4.19±10.14	0.75±1.28	0.99±0.53	20
H. madagascariensis	18.72±14.48	70.31±16.88	1.38±1.65	0.78±1.20	7.70±11.72	0.70±2.14	0.55±1.62	0.82±1.02	19
G. religiosa	20.45±16.80	63.47±14.17	0.86±1.35	0.31± 0.51	9.16±16.63	5.02±8.10	0.03±0.44	0.97±1.02	15

*Oos - Out of sight

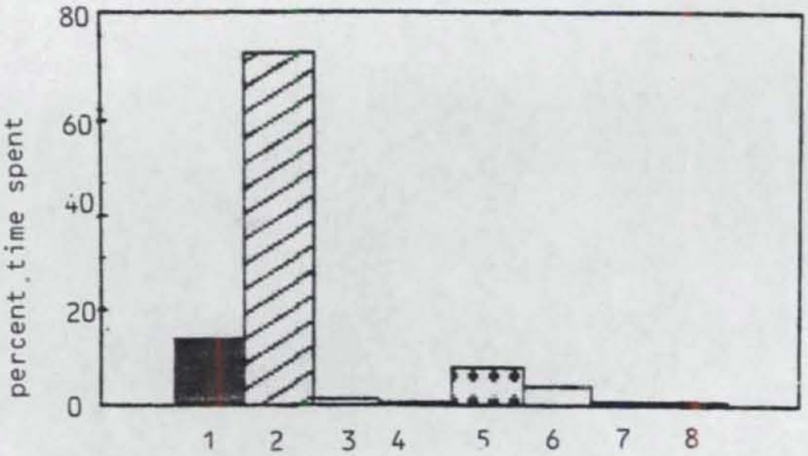
Fig. 21. Percent time spent in activities by (A) Greyfronted Green Pigeon, (B) Small Green Barbet; (C) Crimsonthroated Barbet (Vythiri Site)

1. resting; 2. foraging; 3. locomotion; 4. agonistic; 5. Out-of-sight; 6. preening; 7. courting; 8. Bill cleaning

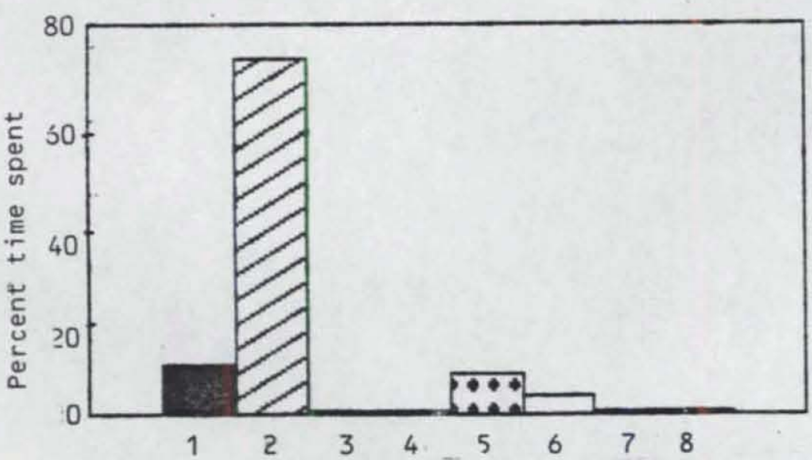
A


80
60
40
20
0
Percent time spent
1
2
3
4
5
6
7
8

B


80
60
40
20
0
percent time spent
1
2
3
4
5
6
7
8

C


80
60
40
20
0
Percent time spent
1
2
3
4
5
6
7
8

22). The pattern of allotment of time for various behavioural activities by these birds varied slightly from that of their counterparts in the Tenhipalam area. The fruit pigeon T. pompadora behaved more or less similarly as its congeneric species T. Phoenicoptera at Tenjhipalam. The barbet M. virdis showed considerable variations in the time allocation pattern between the two sites. The Crimson-throated Barbet,(M. rubricapilla) however, showed a more or less similar foraging behaviour as that of its close relative, the crimson-breasted Barbet (M. haemacephala) in the Site I.

Foraging

The pigeon Treron pompadora foraged for 50 to 60% of total time ($\bar{x}$ 51.38%) wheras the barbets M. virdis and M. rubricapilla spent three-fourth of the time budget in feeding activities. The bulbul H.madagascariensis had incurred an average 70% of time while the Hill Myna (G. religiosa) spent about 60% of time for feeding. Most species of birds here, thus allocated a greater porportion of time for feeding purposes relative to their counterparts in the first study area.

Resting and Preening

The Barbet, the Black Bulbul and the Hill Myna rested and

97 P

Fig. 22. Percent time spent in activities by

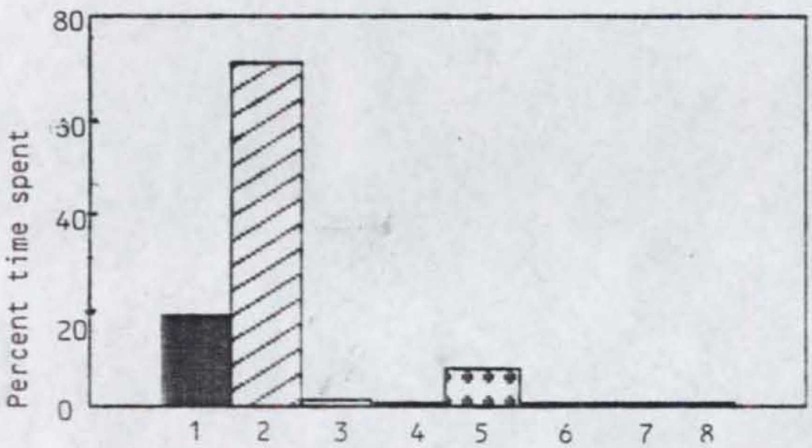
(A) Black Bulbul (B) Hill Myna

1. resting; 2. foraging; 3. locomotion;

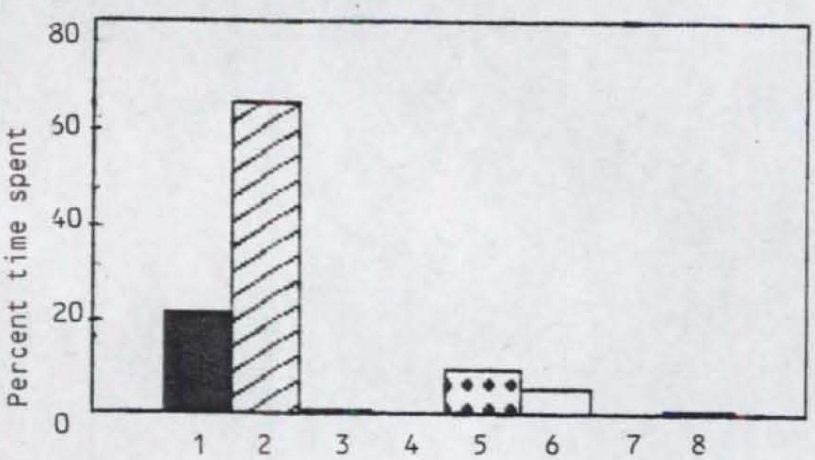
4. agonistic; 5. Out-of-sight; 6. preening;

7. Courting; 8. Bill cleaning.

A



B



Avian Activity

preened for much less time. They allocated about 10 to 20% of time for resting and nearly 4 to 5% of time for preening purposes. These species usually had much shorter feeding bouts and they often flow to a neighbouring perch tree after each visit. The foraging tree was used as perch site only rarely. The Grey-fronted Green pigeons here spent almost as much time ($\bar{X}$ 37.32%) time as the common Green Pegion in the Thenhipalam study area. ($\bar{X}$ 36. 68 %).

Flight

The bird movements other than for foraging or courtship were less prominent in the five frugivore species studied. The Black Bulbul alloted the maximum proportion of time ($\bar{X}$ 1.38 %). for non-foraging movements among these five species of birds. The bulbuls were observed making several untargeted flights, at times moving away from the foraging tree and returned immediately to forage again. Barbets and Hill Myna spent about 1% time for these miscellaneous flights while the fruit pigeon spent only as low as 0.27 % of total time for these locomotions. Pigeons were more sedentary in habit and each member of the flock often foraged for most of the time on a particular branch.

Agonistic

Negative interactions within the frugivore community attending a fig crop were little observed at Vythiri site. Aggressive encounters between foraging birds were never observed during this study. Competitions when observed were mostly intraspecific and often consisted of supplanting chases only. This would have enabled attacking bird to locate the ripe figs. All the five birds species studied had apportioned much less time (<1%) in chasing or agonistic activities.

The avian frugivores in this aea, however, faced severe competition from certain mammalian frugivorus like Bonnet Macaque (Macaca radiata), Malabar Giant Quirrel (Ratufa indica) etc. The bats Pteropus sp. were usually nocturnal visitors. The monkey was more aggressive and was found to scaring off the foraging birds. Most of the avian visitors fled just as the monkey troup marched in on the fig tree.

Courtship

Eventhough less intensive, courting displays were also allocated a small portion of time by many bird species. Mutual courting chases were the most commonly observed mating displays especially in barbets and bulbuls. The Crimson-throated Barbet, the small Green Barbet, and the Black Bulbul spent average 0.75%, 0.52% and 0.55% of time budget respectively in courtship during foraging. In fruit

TABLE 29a. **Analysis of variance of percentage of time allocation for various activities by important bird species at Vythiri site**

Bird species	DF	F-value	Prob.
T. pompadora	7	30.46	< 0.001
M. rubricapilla	7	165.85	< 0.001
M. virdis	7	90.81	< 0.001
H. madagascariensis	7	137.57	< 0.001
G. religiosa	7	72.41	< 0.001

Plate 15. a. A female koel at F. amplissima crop defending its feeding territory.

b. Small Green Barbet swallows the F. amplissima fruit.

PLATE 15

a

b

pigeon, the mating pairs were seen perching side by side. At times one member of the pair, perhaps the male, approached its mate with slow flickering of wings. The breeding pair was seen, very occasionally, making dancing moves by hoping between adjacent branches. This species has allowed an overage 0.37% of time for courtship manoeuvores while attending figs. The Hill Myna spent only a very negligible portion of time in these activities (0.03%).

Cleaning

The Figs of _F. amplssima_ were small enough to be swallowed whole by various species of birds. So very little fruit scraps often stick to the beak after each feeding attempt. The foragers, did not require frequent cleaning of their bill. The crimson-throated Barbet, Grey-fronted Green Pigeon, Hill Myna and Black Bulbul spared only about 1% time for bill cleaning. The Small Green Barbet allocated a slightly lower amount of time (0.73%) to bill cleaning.

Out-of-Sight

Though the ripe fig borne trees were bare or thinly foliated, the smaller birds like barbets got lost from observers vision at times because of the rampant foraging movements of the flock members within the canopy. The Small Green Barbet, Crimson-throated Barbet and Black Bulbul were lost in view for average 7.44%, 8.42% and 7.70%

time respectively. The Hill Myna, which preferably foraged at the upper and outer surface of fig canopy was more difficult to be observed. It remained out-of-sight for an average 9.16% time. The Grey-fronted Green Pigeons because of their more sedentary feeding habit could be more easily traced and were thus lost in view for only a shorter time (3.10%).

FRUIT HANDLING TECHNIQUES AND FORAGING BEHAVIOUR

T. N. Vijayakumar "Resource utilization by birds attending figs in South India"
Thesis. Department of Life Sciences , University of Calicut, 1994

CHAPTER 6

FRUIT HANDLING TECHNIQUES AND FORAGING BEHAVIOUR

A definite strategy seems to have been adopted by avian frugivores in fig gathering and manipulation. Most of them haunted the fruiting fig crown in small, moderate or large sized groups. The mean group size of different foraging species at Tenhipalam site varied considerably and in a bird species itself the group size varied in different fig species. Green pigeons and Greyheaded Myna foraged in much larger flocks of upto 40 or more birds. Crows visited the fig tree often in flocks of 20 or more birds, especially in their evening bouts. Barbets were feeding in flocks of 10 to 15 birds while the Koel and parakeets were seen feeding in pairs or in smaller groups of 6 or 7 birds each. The Redwhiskered Bulbul, the Redvented Bulbul and the Common Myna also foraged in smaller groups (5 or 6 birds each). The Tree Pie usually visited the figs singly or in pairs. While the Large Indian Cuckooshrike was often a lone visitor.

Different species of birds showed variation in their foraging patterns. Before moving to the feeding tree, the fruit pigeons often landed on a tall tree top located nearby. From the sentinel perch they had a look-out of the surroundings. The koel also showed

TABLE 30. **Use of different foraging 'angles' by various avian frugivores at Tenhipalam Site.** N - Sample size; SD in brackets

Spp. Bird	"Upside — down"		"Reach"		Sally / hovering		N
	% time used	% Success	% time used	% success	% time used	% success	
E. scolopacea	38.48 (26.16)	84.20 (18.52)	61.52 (26.16)	94.84 (8.77)	--	--	24
M. virdis	30.45 (21.18)	86.50 (15.35)	69.55 (21.18)	95.41 (10.08)	--	--	38
M. haemacephala	41.13 (27.00)	80.95 (16.59)	58.87 (27.00)	93.58 (14.47)	--	--	25
T. phoenicoptera	34.28 (23.01)	82.42 (23.32)	65.72 (23.01)	94.84 (8.95)	--	--	23
T. cyanocephala	46.72 (33.17)	84.50 (9.34)	53.28 (33.17)	94.17 (11.20)	--	--	15
P. cafer	41.35 (35.98)	58.39 (26.69)	58.65 (35.98)	71.34 (18.05)	--	--	13
C. macrorhynchos	17.87 (17.87)	48.18 (25.97)	75.92 (15.87)	65.68 (15.58)	6.21 (9.28)	25 (28.56)	14
D. vagabunda	37.29 (32.24)	57.35 (33.29)	53.80 (32.88)	74.00 (19.93)	8.91 (12.53)	40 (41.83)	12
A. tristis	30.56 (17.14)	71.49 (17.43)	65.82 (18.10)	83.14 (14.62)	3.61 (6.21)	43.33 (36.52)	18
O.oriolus	25.30 (19.36)	72.75 (21.96)	67.80 (23.81)	77.56 (21.27)	6.90 (9.64)	41.67 (33.33)	21
O. xanthornus	21.57 (18.18)	69.89 (32.34)	71.36 (25.50)	77.01 (17.90)	7.07 (11.17)	36.67 (41.50)	14
C. novaeholandiae	28.13 (26.33)	30 (44.72)	43.20 (32.20)	56.95 (33.51)	28.68 (35.61)	40 (25.28)	9

similar behaviour patterns at times. It was found to maintain feeding territory and was intolerant to others encroaching their territory. They were shy and very clumsy and preferably foraged in shades of foliage. Pigeons and Koels were usually quite silent whilst feeding. The Pigeon, however, was heard producing mute calls either at rest or in interfeeding intervals. The Small Green Barbet produced low contact calls while foraging. The male Koel was observed feeding the female with ripe figs during the breeding season. The Blossom-headed Parakeet and the Rose-ringed Parakeet landed on the upper surface of fig canopy. They made loud contact calls while at landing and at departure. They also foraged silently with fewer foraging moves. This made them very difficult to be traced within the tree canopy. Crows made rather frenetic movements producing vociferous calls annoying other frugivores. The Koel found themselves crouching behind foliage in such circumstances.

Distinct fruit monoeuvring techniques were employed by different species of birds to gather figs. These techniques mainly depended on the morphology, mode of presentation and spatial arrangements of figs on the tree as well as the morphological features of the foraging bird species. Three majour techniques were adopted by birds to pluck figs presented at the tip of small twigs or on the trunk; (1) the "Hanging" or "Upside Down" position in which the feeding bird hanged head-down or upside down from fruit-bearing branch or twig and plucked the figs; (2) the "Reach" position, when the visitor extended its head and neck and reached out the fig from perch; (3) the "Sallying" or "Hovering" tactics in which the bird picked up figs from very thin or drooping twigs while on wings.

Majority of fig-eaters used the first two feeding angles quite commonly and only spairingly they depended on "hovering" or "sallying" technique. The table 30 describes the mean percentage of times each technique was employed by various bird species at Tenhipalam site and respective success rate of each species using each tactics.

The Koel, Small Green Barbet, Copper Smith Barbet and Red-vented Bulbul used "reach" and "upside down" positions almost similarly and in nearly 60% and 40% of times respectively. Fruit pigeons used the "reach" and the "upside down" angles in about 60-65% and 35-40% of times respectively. Parakeets were equally efficient at both the above positions, though the "reach" position was used more often ($\overline{X}$ 53.28% and $\overline{X}$ 46.72% respectively). The jungle crow had a much greater number of attempts at "reach" angle than in the "upside down" position.

The Golden Oriole, Black-headed Oriole, Tree Pie and Common Myna had similar foraging patterns and they used all the three different feeding techniques, though the "reach" and "upside down" angles were more prominent (Table 30). The "Sallying" or "hovering" flight tactics was used in less than 10% of the total feeding attempts. The Large Indian Cuckoo Shrike also employed the three different feeding modes. This species was more efficient at "Sallying" technique than other avian frugivores in this study area. It used the other two positions with almost equal efficiency, but the "reach" position was more prominent (Table 30).

The number of successful attempts at each angle by different bird species differed considerably. The same species had different success rates at different angles (Table 30). The specialists such as Koel, Small Green Barbet, Copper-smith Barbet, Common Green Pigeon, Grey-fronted Green Pigeon and Blossom-headed Parakeet had similar and over 80% success rates at "Upside down" position and about 95% successful attempts at "reach" position. The Red-vented Bulbul, Golden Oriole, Black-headed Oriole and Common Myna were almost equally efficient in the first two positions with about 70% successful attempts in each case while scoring only 40 to 50% success in the "sallying" or "hovering" tactics. The Jungle Crow and Tree Pie had almost similar success rates at the first two positions (Table 30). The Tree Pie, however, was more successful than Crow at "sallying" or "hovering" technique. The Large Indian Cuckoo Shrike had a little lower success rates at "upside down" (30%) and "reach" (56.95%) positions than other bird species. However, with "flight" technique, they had over 60% success rate.

TABLE 31. **Use of different foraging 'angles' by various avian frugivores at Vythiri site** (Standard deviation in parentheses; N = sample size)

Spp. Bird	"Upside — down"		"Reach"		Sally / hovering		N
	% times used	% Success	% times used	% success	% times used	% success	
T. pompadora	32.77 (16.65)	88.09 (13.99)	67.28 (16.62)	92.13 (9.85)	--	--	25
T. griseus	7.52 (11.88)	18.33 (21.34)	92.48 (11.88)	83.70 (13.47)	--	--	11
P. columboides	56.89 (30.23)	67.49 (31.28)	43.11 (30.23)	81.19 (18.12)	--	--	9
M. virdis	28.64 (12.37)	89.87 (13.88)	71.36 (12.37)	92.83 (16.68)	--	--	14
M. haemacephala	41.76 (21.10)	84.70 (14.62)	58.31 (21.11)	91.44 (12.18)	--	--	12
P. jocosus	25.67 (22.10)	71.67 (26.12)	71.67 (21.18)	75.78 (19.90)	2.67 (7.04)	75 (35.36)	15
H. madagascariensis	24.44 (24.13)	80.59 (20.66)	57.63 (33.63)	72.99 (31.12)	17.30 (29.82)	68.18 (20.96)	30
T. merula	26.53 (23.22)	77.71 (34.14)	67.71 (24.53)	93.32 (8.91)	5.67 (9.17)	83.33 (28.87)	10
G. religiosa	23.74 (25.90)	88.10 (20.89)	70.62 (32.80)	89.77 (16.11)	5.67 (9.17)	83.33 (28.87)	10
I. puella	7.85 (14.79)	87.50 (25)	31.15 (29.06)	91.33 (14.42)	61.67 (27.46)	80.62 (20.40)	14

The Koel and the Small Green Barbet usually swallowed the figs whole or after a brief manipulation by bill when the figs were large. The Copper-smith Barbet swallowed the smaller figs of *F. tsjahela*, *F. microcarpa*, *F. gibbosa* etc. while it had a piece-meal diet of larger ones like that of *F. benghalensis*. A similar behaviour was observed in Fruit Pigeon, Oriole, Myna and Bulbul. Crows and Tree Pie had a rather clumsy way of fig manipulation. They moved over to other perching branches after picking up the figs which were then held in claws or between toes and consumed bit-by-bit. Scraps of figs containing pulp and seeds were dropped on the ground. The Large Indian Cuckoo Shrike generally flew over to a nearby tree after plucking the figs to eat them. It usually banged the fig several times against the perching branch as it used to do with an animal prey.

The conspecific and mixed feeding flocks characteristic of avian frugivory were of common occurrence in the Vythiri Study area also. The mean group sizes of various frugivores varied considerably. The Grey-fronted Green Pigeon and the Crimson-throated Barbet had feeding flocks of upto 50 or more birds. The White eyes were seen visiting fig crown in considerably large numbers. Groups of Hill Myna and Black Bulbul often comprised of 10 to 12 birds while that of the Small Green Barbet contained 10 or more birds. The Blue-Winged Parakeet, the Imperial Pigeon, the Malabar Grey Hornbill etc. formed

TABLE 32. **Success of feeding different on branch categories (Site I)** (Date in bracket is standard deviation)

Spp. Bird	Branch category ONE			TWO			THREE			FOUR			N
	No visits	% total visits	% success	No visits	% total visits	% success	No visits	% total visits	% succ ess	No visits	% total visits	% success	
E. scolopacea	5.78 (3.77)	58.57 (27.36)	89.44 (11.80)	3.48 (2.63)	30.70 (21.54)	97.33 (6.54)	1.04 (1.55)	7.90 (11.65)	100	0.43 (0.79)	2.83 (4.95)	100	23
M. virdis	8.64 (4.64)	69.46 (19.73)	95.76 (19.73)	2.6 (2.28)	21.26 (15.34)	96.67 (8.80)	0.70 (1.17)	5.60 (7.97)	100	0.45 (0.94)	3.50 (8.05)	91.67 (16.67)	20
M. haemacephala	8.47 (5.19)	68.53 (21.47)	94.52 (7.41)	3.88 (3.50)	24.92 (19.10)	92.49 (11.76)	0.50 (0.86)	3.68 (5.93)	86.11 (22.15)	0.39 (0.85)	2.55 (5.49)	54.17 (41.67)	17
T. phoenicoptera	8.32 (4.04)	59.14 (18.90)	93.06 (10.29)	4 (2.63)	30.81 (16.23)	97.64 (6.56)	1.04 (1.21)	6.42 (7.85)	100	0.68 (1.03)	3.60 (5.56)	100	25
P. cafer	4.92 (2.50)	79.72 (17.91)	66.64 (22.52)	1.69 (1.60)	20.28 (17.91)	82.29 (20.14)	--	--	--	--	--	--	13
P. jocosus	3 (2)	80.56 (18.78)	83.51 (19.47)	0.75 (0.71)	19.44 (18.78)	90 (22.36)	--	--	--	--	--	--	8
C. macrorhynchos	5.65 (2.89)	45.98 (18.92)	48.08 (17.32)	3.80 (1.54)	32.94 (11.96)	62.69 (22.84)	1.65 (1.31)	12.00 (9.86)	77.22 (29.21)	1.15 (1.73)	8.07 (10.64)	88.89 (19.24)	14
C. splendens	3 (2.45)	34.08 (27.07)	57.75 (20.80)	3.31 (2.06)	39.09 (20.09)	63.88 (18.51)	1.38 (1.45)	15.80 (20.27)	72.62 (20.81)	0.92 (1.12)	10.53 (12.49)	69.44 (40.02)	13
D. vagabunda	4.14 (2.18)	57.39 (18.08)	69.45 (27.62)	1.71 (0.83)	27.88 (19.82)	83.33 (31.18)	0.86 (1.17)	10.44 (12.78)	82.14 (37.40)	0.36 (0.63)	4.28 (7.14)	85 (30)	14
A. tristis	8.13 (4.16)	63.66 (22.69)	86.43 (15.41)	3.75 (2.54)	28.83 (18.48)	92.33 (11.75)	0.63 (1.31)	4.22 (2.29)	100	0.50 (0.97)	3.19 (0.97)	100	16
O. oriolus	6.26 (3.93)	62.31 (28.02)	84.89 (17.12)	2.24 (0.97)	26.62 (18.03)	92.45 (15.14)	0.68 (1.20)	6.46 (12.14)	95.23 (10.21)	0.47 (1.07)	3.56 (8.44)	100	19
S. malabaricus	10.90 (4.43)	81.68 (12.82)	62.84 (9.28)	2.8 (2.39)	18.32 (12.79)	64.94 (35.13)	--	--	--	--	--	--	10

TABLE 33. **Success of feeding at different branch categories (Site II)** (Data in parentheses is standard deviation)

Spp. Bird	Branch category: ONE			TWO			THREE			FOUR			N
	No visits	% total visits	% success	No visits	% total visits	% success	No visits	% total visits	% success	No visits	% total visits	% success	
<u>T. pompadora</u>	11.45 (7.61)	58.64 (23.51)	87.39 (13.06)	5.25 (5.18)	26.31 (23.09)	97.11 (7.12)	2.7 (3.01)	11.24 (10.75)	96.03 (10.32)	1.1 (2.61)	4.86 (9.91)	100	20
<u>T. griseus</u>	--	--	--	3.256 (3.49)	37.04 (35.55)	77.30 22.17)	5.75 (6.50)	34.90 (15.75)	86.79 (13.21)	5.3 (5.58)	27.77 (27.26)	95.0 (6.85)	8
<u>P. columboides</u>	3 (2.5)	37.14 (32.23)	70.94 (14.67)	4.11 (2.52)	49.19 (30.91)	65.61 (32.43)	1.25 (1.58)	11.75 (13.01)	91.67 (16.67)	0.63 (1.19)	7.68 (15.06)	100	9
<u>M. virdis</u>	7.09 (3.13)	59.99 (17.45)	91.70 (9.86)	3.05 (1.50)	24.72 (10.85)	96.50 (9.01)	0.86 (1.04)	6.32 (7.64)	96.67 (10.54)	0.95 (1.40)	7.45 (10.70)	100	22
<u>M. rubricapilla</u>	8.75 (3.75)	64.86 (16.59)	86.60 (14.06)	3.45 (2.74)	23.07 (11.75)	92.02 (12.55)	1.55 (1.67)	9.68 (10.89)	91.67 (16.67)	0.50 (0.95)	2.87 (5.35)	55.56 (45.54)	20
<u>P. jocosus</u>	5.09 (3.11)	70.64 (24.70)	74.35 (19.05)	2 (1.90)	18.65 (16.34)	84.29 (21.49)	1 (1.10)	9.21 (10.90)	55 (46.37)	--	--	--	11
<u>H. madagascariensis</u>	4.05 (1.76)	64.21 (21.38)	73.29 (18.93)	2.2 (1.47)	30.83 (18.35)	81.86 (21.70)	0.25 (0.64)	2.67 (6.54)	83.33 (28.87)	0.15 (0.37?	2.29 (6.26)	66.67 (57.79)	20
<u>G. religiosa</u>	3.64 (2.62)	40.54 (26.86)	80.45 (19.58)	2.91 (1.76)	32.17 (16.30)	84 (18.83)	1.54 (1.44)	20.30 (20.74)	95 (14.14)	0.73 (1.19)	6.98 (10.60)	100	11

relatively Smaller conspecific foraging groups. Usually 6 to 8 birds were found in the foraging groups of Red-whiskered Bulbul. The Black Bird and the Blue Bird foraged singly or in pairs. The flock sizes of other infrequent avian visitors were not recorded.

The ecological peculiarities of Vythiri site, had slightly modified the behavioural patterns of fruit-eating birds. Most of the species, particularly the smaller frugivores like barbets and bulbuls performed several much shorter feeding bouts. After each feeding bout they flew on to nearby foliage canopies. This probably, helped them to avoid predation. The fruit pigeon usually perched on nearby and mostly leafless tree top and scanned the neighbourhood before visiting the fruiting fig.

The fig-gathering techniques of 10 species of birds were studied here. Three important tactics were employed by various species of birds (Table 31). The Grey-fronted Green Pigeon, Malabar Grey Hornbill, Blue-winged Parakeet, and barbets largely used the "upside down or hanging down" and "reach" positions in plucking figs while Red-whiskered Bulbul, Black Bulbul, Hill Myna and Blue Bird used the third and "Sally" or "hovering" techinque also. The fruit pigeon and Hornbill utilised the "reach" position significantly greater times than the "Upside down" Position (x^2 = 18.33, x^2 = 36.09; $P < 0.001$ respectively). The Small Green Barbet, the Black Bird and bulbuls used the "reach" and "head-down" positions more or less similarly.

TABLE 34. **Use of different foraging heights by important frugivores at site I.**

Figures are means of number of vitis per bout (Data in parenthesis is mean percentage)
LB - Lower Branch, MB - Middle Branch, UB - Upper Branch

Sl. No.	Bird species	LB	MB	UB	N
1.	*E. scolopacea*	3.62 (31.37)	4.92 (42.63)	3.0 (26.0)	13
2.	*M. virdis*	9.38 (26.8)	12.54 (35.83)	13.08 (37.37)	13
3.	*M. haemacephala*	1.50 (8.73)	5.38 (31.30)	10.31 (59.58)	18
4.	*T. phoenicoptera*	1.62 (9.88)	4.15 (25.32)	10.62 (64.80)	13
5.	*T. pompadora*	2.77 (15.03)	6.33 (34.35)	9.33 (50.62)	9
6.	*P. cyanocephala*	0.63 (8.45)	3.33 (44.64)	3.5 (46.92)	8
7.	*C. macrorhynchos*	33.75 (25)	6.75 (45)	4.50 (30)	8
8.	*A. tristis*	4.43 (35.81)	6.38 (51.58)	1.50 (12.13)	9
9.	*O. oriolus*	1.44 (10.99)	7.33 (55.95)	4.33 (33.05)	8

The Blue-Winged Parakeet picked up figs in the "head down" Position (56.89%) slightly more frequently than in "reach" position (X 43.11%). The Blue birds were more adept at "Sallying" or "hovering" tactics (61.07%). They had significantly greater use of this technique than other avain frugivores (P > 0.001, Chi-squre). The "Sally" or hovering technique used less frequently but quite efficiently by Black Bird, Hill Myna and Bulbul.

The efficiency and success rates of various feeding techniques varied in different species of birds. The Green Pigeon, Hill Myna, barbets and Blue Bird had almost similar and high success rates at "upside down" and "reach" positions (> 90% success rate). The Blue-winged Parakeet, Black Bird and bulbuls were slightly less successful at "upside down" or "hanging down" positions (Table 31). The Malabar Grey Hornbill had much lower success rate at "upside down" angle ($\overline{X}$ 18.33%) while it used the "reach" position with significantly greater efficiency (x^2 = 41.86; P < 0.001).

Use of Foraging Sites

Differences were observed in the use of foraging sites by various avian frugivores. In the present study the fruiting tree crown, whenever possible, was vertically divided into three categories of foraging sites viz; the lower branch (LB); mid-branch

(MB); and the upper branch (UB). These foraging sites were defined by dividing the total tree heights into thirds (Porter et al., 1985). The visually observed foraging heights were assigned to the appropriate categories.

The foraging sites were also classified into four categories namely "1", "2", "3", or "4" according to the thickness or diameter of perching branches from where a bird species plucked figs. Sample measurements of different fruit-bearing branches were taken and the observed branches were then assigned to appropriate categories. The category "1" branches were < 1 cm in diameter; the "2" branches were between 1 cm and 2 cm in diameter; the "3" category branches were between 2 cm and 3 cm in diameter and the "4" type branches had more than 3 cm diameter. The frequency with which the different fruit-eating species foraged at different foraging sites varied considerably. The table 34 describes the vertical distribution of foraging sites of eleven species of frugivores in the Tenhipalam site.

Birds such as Copper-smith Barbet and Grey-headed Myna foraged mostly on upper branches. The Koel, Jungle Crow and House Crow tended to forage more frequently on mid-branches and with moderate frequencies among the upper and lower branches (Table 34). The Common Green Pigeon and Grey-fronted Green Pigeon were using upper branches more frequently (62.94% and 50.60% respectively). They were least dependent on the lower branches. A similar foraging pattern and site use were seen in Copper-smith Barbet (UB > MB > LB). While the Small Green Barbet was very active at all the three sites, though slightly less dependent on lower branches (Table 34). The Blossom-headed Parakeet used mostly upper and middle branches. Only about 10% foraging attempts were made at lower branches.

The Common Myna and the Tree Pie had similar foraging patterns and they used the three different branches in the order MB > LB > UB. The Golden Oriole was more freqently feeding at the upper branches than the lower branches ($P < 0.05$; Runs test, table 34a). No significant differences were found between the Koel and the Small Green Barbet and between the Koel and the Jungle Crow ($P > 0.30$, Chi-square test, table 34b).

There are considerable variations in the distribution of different branch categories used by various frugivores. Table 32 describes the average number and percentage of times each of the 4 branch categories was used by the bird species in a foraging visit on F. amplissima. The relative proportion of successful attempts on each of these branch type is also shown in the table. In majority of the Ficus species studied, figs were mostly borne on small twigs or branches and most of the frugivores foraged mainly from the "1" or "2" category branches. However, the branch categories were used

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TABLE 34a. **Foraging site dependence (Tenhipalam Site)**

Runs test (Significance level 0.05)

Sl. No.	Bird species	Foraging Site	r	P
1.	*E. scolopacea*	UB / MB	28	0.001
		UB / LB	34	< 0.001
		MB / LB	26	0.005
2.	*M. virdis*	UB / MB	29	0.15
		UB / LB	32	0.03
		MB / LB	28	0.23
3.	*M. haemacephala*	UB / MB	26	0.14
		UB / LB	14	0.004
		MB / LB	24	0.49
4.	*T. phoenicoptera*	UB / MB	20	0.50
		UB / LB	6	< 0.001
		MB / LB	20	0.50
5.	*C. macrorhynchos*	UB / MB	6	0.10
		UB / LB	13	0.96
		MB / LB	10	0.62
6.	*C. splendens*	UB / MB	15	0.99
		UB / LB	12	0.99
		MB / LB	17	1.00
7.	*A. tristis*	UB / MB	6	0.21
		UB / LB	8	0.62
		MB / LB	12	1.00

TABLE 34b. **Foraging site use - interaction with other species.** Chi-square analysis (Tenhipalam Site) (Codes for birds as in table 5) (Significance level 0.05)

Interacting species	Chi-square value	P
ES / MH	4.23	0.12
ES /MH	17.67	< 0.001
ES / TP	31.82	< 0.001
ES / TR	14.43	< 0.001
ES / PC	12.64	< 0.002
ES / CM	0.738	0.691
TP / MV	18.69	< 0.001
TP / MH	3.01	0.22
TP / TR	4.32	0.11
TP / CM	24.43	< 0.001
MV / MH	7.349	< 0.03
MV / TR	5.52	0.06
MV / CM	1.269	0.53
MH / TR	0.181	0.914

differently with different success rates by various frugivores. Many of the fig-bearing twigs or branches were small enough to support larger frugivores such as Koel, Green Pigeon, Crow, common Myna, Oriole, Parakeets etc; But smaller forgers like Copper-smith barbet, Small Green Barbet, Grey-headed Myna, bulbuls and Flower peckers could pick up the figs from these branches with greater ease.

The Small Green Barbet, Copper Smith Barbet, Grey-headed Myna and Red-vented Bulbul had nearly 70 to 80% of their feeding attempts on the '1' category branches and around 20% of the visits on the '2' branch category. The two barbet species did have a very few attempts on "3" and "4" branch categories, while the other two species completely avoided these branch sites. The Koel, Common Green Pigeon Golden Oriole, Common Myna and Tree Pie had similar visitation patterns and they made nearly 60% of their feeding visits on the branch "1" and 25 to 30% of visits to branch "2" and 5 to 10% of visits to branch "3". The "4" branch sites were used in less than 5% of attempts only. The Jungle Crow and the House Crow used the "2" and "3" category branches more frequently than the smaller birds like Coppersmith Barbet.

The proportion of successful feeding attempts also varied considerably among different bird species. The Small Green Barbet, Coppersmith Barbet and Common Green Pigeon were the most successful species on branch "1" category with over 90% success rate. The Koel also had a higher success rate (89.44%). The Golden Oriole and the Common Myna with about 85% successful visits achieved the highest success rate among opportunists.

The Tree Pie had an average 69.45% successful attempts while both the Jungle and House crows had only about 50% success rate at these sites. The Red-vented Bulbul and Grey-headed Myna had more or less similar success rate on the branch "1" category (Table 32).

Greater success rates were recorded on the other three branch types by most of the avian frugivores. The Koel and the Common Green Pigeon reached 95 to 100% success rate at "2", "3", and "4" category branches. The Small Green Barbet had a mean 91.67% successful attempts on the "4" branch site while it scored over 95% sucess rates on the "2" and "3" branch types. Coppper-smith Barbet attained a little lower sucess on 2nd and 3rd category branches ($\bar{X}$ 92.49% and $\bar{X}$ 86.11% respectively). On the "4" category branches it had only about 50% successful bouts. This species often failed in reaching out for the figs from these sites. The Golden Oriole and the Common Myna also attained greater success rates at these three branch types (Table 32). The crows, were more adept at "2", "3", and "4" branch types than at "1" category branch. However, they had much lower success rates than either the specialists or the opportunists like Golden Oriole and Common Myna. The relatively smaller figs of _F. amplissima_ often slipped off their beaks.

TABLE 35. **Use of different foraging heights by various important avian frugivores at site II.**

LB - Lower Branch; MB - Middle Branch; UB - Upper Branch (Figures are mean number of visits per bout. Data in parentheses are mean percentage).

Sl. No.	Bird species	LB	MB	UB	N
1.	*T. pompadora*	2.19 (8.33)	6.53 (31.36)	14.12 (60.30)	
2.	*M. virdis*	2.33 (21.60)	4.30 (40.32)	3.46 (38.05)	
3.	*M. rub ricapilla*	5.26 (19.95)	9.21 (35.06)	12.16 (44.99)	
4.	*T. griseus*	3 (27.79)	3.5 (31.44)	6 (40.76)	
5.	*D. badia*	2.75 (17.55)	6.5 (44.18)	6.20 (38.27)	
6.	*H. madagascariensis*	2.30 (12.96)	7 (35.33)	9.36 (51.70)	
7.	*P. jocosus*	6.67 (24.31)	9.25 (46.88)	7.60 (28.82)	
8.	*G. religiosa*	1.36 (7.45)	4 (24.78)	8.64 (61.77)	

The Tree Pie scored over 80% success at these three branch categories. The Red-vented Bulbul and Grey-headed Myna had 64.94% and 82.29% successful bouts respectively on "2" branch while both the species made no feeding attempts at "3" and "4" branch sites.

The differential use of various foraging sites or branches by eight species of birds were studied at Vythiri site (Table 33). Data were collected from observations on *Ficus amplissima* trees. All bird species except the Malabar Grey Hornbill and the Redwhiskered Bulbul utlised the four different branch categories. The former species had no feeding attempt on branch "1" as the birds were large enough to be supported by those branches. The Red-whiskered Bulbul, on the otherhand, avoided the "4" branch category as the species could not reach out for figs from this site.

The Crimson-throated Barbet, the Small Green Barbet, the Red Whiskered bulbuls, Black Bulbul and the Green Pigeon had more or less similar visitation patterns ($P > 0.30$, Chi-square test). The "1" category branches were used for nearly 65 to 70% of times while the "2" category branches in 20 to 30% of attempts by these bird species. The Blue-Winged Parakeet made about 1/3 of total feeding attempts on branch "1" and about 1/2 of visits on branch "2" while the Hill Myna depended on both the branch sites almost equally (Table 33). The Malabar Grey Hornbill had most of their feeding visits on "2" and "3" branches ($\bar{X}$ 37.04%; $\bar{X}$ 34.90% respectively) while the "4" branch types were used less frequently (Table 33). Other avian frugivores had considerably lower dependence on the "3" and "4" category branches.

The success rates at different branch sites varied considerably in different species of birds. Fruit pigeon and barbets had the highest success rates at the first two branch categories (> 90%). The Blue-winged Parakeet, Red-whiskered Bulbul. Black Bulbul and Hill Myna were a little less successful at "1" and "2" branches (Table 33). Green Pigeon, Parakeet and Small Green Barbet scored 90 to 100% success rates on "3" and "4" branch sites while Crimson-throated Barbet had significantly lower success rate on "4" branch category ($\bar{X}$ 55.56%; $P < 0.01$). The Hornbill has been significantly less successful on "1" and "2" branch types than on "3" and "4" branch sites. ($P < 0.001$, Chi-square test).

A distinct vertical distribution of foraging sites were observed among various frugivores in the present study. Table 35 describes the differential use of three foraging sites, viz; upper branch, middle branch and lower branch by eight species of birds studied. The Grey-fronted Green Pigeon, Hill Myna and Black Bulbul were significantly more dependent on upper branches than either the middle or Lower branches. ($P < 0.01$, runs test, table 35a). The three sites were used in the order UB > MB > LB. The Small Green Barbet and Crimson-throated Barbet foraged almost equally at upper and mid-

TABLE 35a. **Foraging site dependence of important frugivores (Vythiri Site)**

Runs test (Significance level 0.05)

Sl. No.	Bird species	Foraging Site	r	P
1.	*T. pompadora*	UB / MB	22	0.11
		UB / LB	12	0.14
		MB / LB	14	0.15
2.	*M. virdis*	UB / MB	16	0.97
		UB / LB	24	1.00
		MB / LB	16	0.93
3.	*M. rubricapilla*	UB / MB	28	0.007
		UB / LB	16	0.12
		MB / LB	20	0.50
4.	*G. religiosa*	UB / MB	8	0.06
		UB / LB	4	< 0.001
		MB / LB	14	0.87
5.	*H. madagascariensis*	UB / MB	14	0.87
		UB / LB	9	0.98
		MB / LB	9	0.82
6.	*T. griseus*	UB / MB	4	0.37
		UB / LB	4	0.37
		MB / LB	8	1.00

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Plate 16. a. Small Green Barbet swallowing the small fig.

b. A male Koel at alert in its feeding territory on _F. amplissima_.

PLATE 16

a

b

branch sites (Table 35). They had significantly greater dependence on these sites than on lower branches ($P < 0.005$; $P < 0.007$ respectively, Runs test). All the three foraging sites were utilised almost similarly by the Imperial Pigeon, the Malabar Grey Hornbill and the Red-whiskered Bulbul ($P < 0.15$, Chi-square test). However, the Imperial Pigeon and Bulbul used the mid-branch sites and the Hornhill used the upper branch sites for slightly greater number of times (Table 35).

Foraging Movements

Remarkable variations were observed among various fig-eating species of birds in their ripe-fruit finding strategy and locomotary patterns whilst feeding. Usually two kinds of foraging modes such as 'widely foraging' and 'sedentary' or 'sit-and-wait' foraging were come across. Three types of locomotary activities like 'hop', 'walk' and 'flight' were generally performed by the foraging species. The 'widely foraging' tactics often included several short moves like 'hops' or 'walks'. The sedentarily feeding species using sit-and-wait mode of searching for ripe fruits usually restricted their foraging activity onto a limited portion of the tree crown during each feeding visit. Relatively fewer number of moves were undertaken by these birds in a visit. The smaller bird species like barbets, bulbuls, Myna, Flower-pecker, White eye etc. were widely foraging

TABLE 36. **Foraging movement patterns in 'important' bird species attending *Ficus* crop atTenhipalam site** (n = number of each foraging move; N - total number of foraging movements)

Bird species	HOP		WALK		FLIGHT		N
	n	Percentage	n	Percentage	n	Percentage	
E. scolopacea	58	79.45	4	5.48	11	15.07	73
M. virdis	123	78.34	--	--	34	21.66	157
M. haemacephala	165	77.83	--	--	47	22.17	212
T. phoenicoptera	65	46.10	56	39.72	20	14.18	141
T. pompadora	81	48.79	60	36.14	25	15.06	166
P. cyanocephala	31	34.83	17	19.10	41	46.07	89
C. macrorhynchos	64	58.72	20	18.35	25	22.94	109
A. tristis	73	74.49	7	7.14	18	18.37	98
S. malabaricus	112	72.26	21	13.55	22	14.19	155
O. oriolus	69	76.67	--	--	21	23.3	90

species while Green pigeon, Parakeet, Koel, Hornbill, Imperial pigeon etc. had more or less sedentary foraging habit.

In the present investigation the movement patterns of ten different species of birds in the Tenhipalam site (Table 36) and nine species at Vythiri site (Table 37) were analysed. At site I, the barbets and orioles performed only the 'hop' and 'flight' moves and they had a widely foraging strategy. The Small Green Barbet and the Coppersmith Barbet were quite restless and made upto 60 or 70 'hopping' moves in a single feeding bout. In Golden Oriole nearly 75% of locomotions were hops and 25% included short and long flights across the fruiting tree canopy. The Common Myna and Greyheaded Myna were also widely foraging species. They however used all the three movement patterns, though 'hops' were more frequent (over 70% moves; table 36).

The sit-and-wait strategy of locating ripe figs adopted by Koel, Green Pigeon, Parakeet and Crow necessitated only fewer foraging moves. However they undertook all the three types locomotions. In Koel about 75% of movements were 'hops' and 'walk' and 'flight' moves were taken in 5.48% and 15.07% of times. The Green pigeons made short hop and walk moves with more or less similar frequency (Table 36) while the Blossomheaded Parakeet employed 'flight' slightly more frequently (46.07%) than 'hops' (34.83%) and much more freqently than 'walk' (19.10%). The Jungle Crow during its frantic search for ripe

TABLE 37. **Foraging movements of important birds attending figs at Vythiri site**

(n = number of each foraging move; N = total number of foraging movements)

Bird species	HOP		WALK		FLIGHT		N
	n	Percentage	n	Percentage	n	Percentage	
I. pompadora	152	56.51	90	33.46	25	9.29	269
M. virdis	109	66.46	--	--	55	33.54	164
M. rubricapilla	213	73.70	--	--	76	26.30	289
I. griseus	69	75	--	--	23	25	92
P. jocosus	63	63.64	--	--	36	36.36	99
H. madagascariensis	108	52.94	--	--	96	47.06	204
H. indicus	19	51.35	--	--	18	48.65	37
G. religiosa	68	61.82	17	15.45	25	22.73	110
I. puella	61	49.19	--	--	63	50.81	124

117.0

figs undertook all the three type of movements though nearly 60% of them were of hoping type (table 36).

Similarly at site II various frugivores had adopted different foraging strategies with different locomotary patterns (table 37). The Green Pigeon and Hill Myna made use of all the three types of foraging movements. The Grey-fronted Green Pigeon performed short 'hops' and 'walks' with greater frequency than 'flights'. They, however had a more or less sedentary or sit-and-wait feeding strategy. In Hill Myna about 60% moves were of 'hoping' category. The flight and walk moves were taken in 22.73% and 15.45% of times respectively.

The Hornbill, Barbets, Bulbuls and Blue bird had only 'hop' and 'flight' moves during foraging. The barbets and bulbuls were 'widely foraging' species taking several short moves among the fruiting tree canopy while the Hornbill and Blue birds were having a sit-and-wait mode of foraging. They took relatively less number of foraging movements. Three-fourth of the feeding moves in the Hornbill were of hop category and only one-fourth formed the 'flights'. In Black Bulbul, Yellowbrowed Bulbul and Blue bird both the 'hops' and 'flights' were having more or less similar frequency (table 37). The Red-vented Bulbul made hops and flights for about 63.64% and 36.36% of total movements respectively.

FACTORS INFLUENCING RESOURCE UTILIZATION

T. N. Vijayakumar “Resource utilization by birds attending figs in South India”
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CHAPTER 7

FACTORS INFLUENCING RESOURCE UTILIZATION

The efficient exploitation of figs by avian frugivores were affected by various factors (1) Environmental conditions such as time of day, temperature and rainfall; (2) Fruit size and colour; (3) Temporal seguence of flowering and fruiting; (4) animal association interspecific and intraspecific competitions and predation etc. In the present investigation factors such as time of day, temperature, rainfall, fruit size and association and interaction among different birds were examined. The impact of these environmental factors on resource utilization by four important avian frugivores like *E. scolopacea* *M. virdis*, *M. haemacephala* and *T. phoenicoptera* were assessed in detail. These studies were conducted in the Tenhipalam site as the conditions were not conducive for such observations at Vythiri.

a. Time-of-day

Generally, the avain fruit foraging activities on a fig occurred throughout the day. But the foraging intensity varied differently in different species of birds. A general decline in the

TABLE 38. **Comparative mean number of visits at different times of the day by five important bird species**

Bird species	6.30 - 10.30	10.30 - 14.30	14.30 - 18.30	N
E. scolopacea	8.1 ± 1.29	4.4 ± 1.51	7.4 ± 1.25	10
M. virdis	11.73 ± 2.96	8.33 ± 2.13	11.50 ± 1.74	15
M. haemacephala	10.81 ± 2.08	7.54 ± 2.91	10.36 ± 2.25	11
T. phoenicoptera	7.5 ± 1.90	3.3 ± 1.57	5.9 ± 1.60	10
C. macrorhynchos	5.63 ± 3.16	1.67 ± 1.94	6.3 ± 2.74	9

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TABLE 39. **Length of feeding bouts and rates of feeding at different temperatures.**

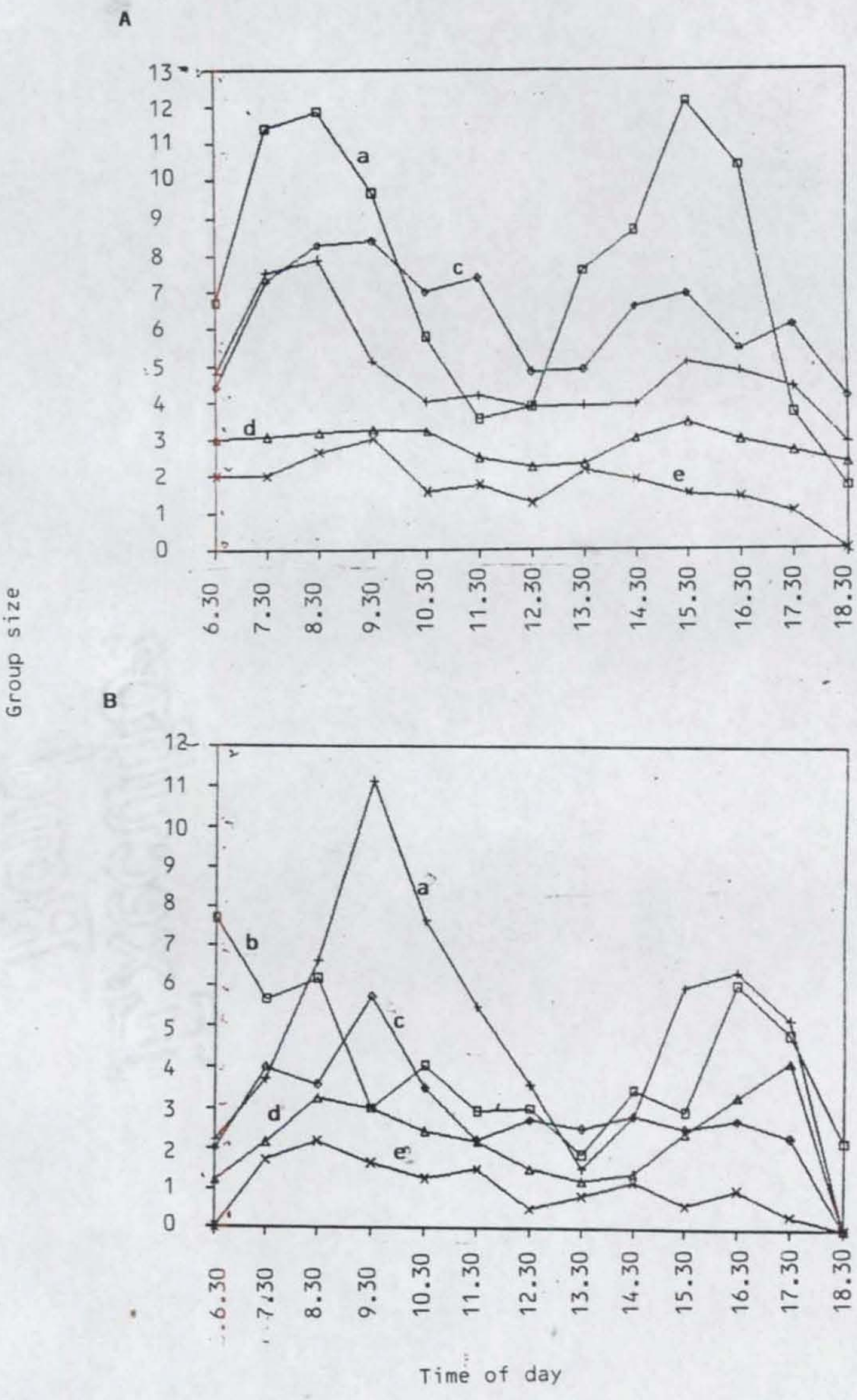
Figures are means with standard deviation

Bird species	Feeding Bout			Feeding Rate		
	25 - 20^{o}C	25 - 30^{o}C	30 - 35^{o}C	20 - 25^{o}C	25 - 30^{o}C	30 - 35^{o}C
E. scolopacea	780.20 ± 266.83	943.13 ± 392.12	342.93 ± 245.95	0.28 ± 0.12	0.33 ± 0.18	0.16 ± 0.15
M. virdis	682.46 ± 449.95	725.85 ± 403.22	329.85 ± 133.29	0.41 ± 0.23	0.36 ± 0.17	0.22 ± 0.10
M. haemacephala	850.90 ± 223.34	747.55 ± 354.74	497.18 ± 276.65	0.19 ± 0.05	0.23 ± 0.13	0.17 ± 0.09
T. phoenicoptera	1103.64 ± 512.79	728.43 ± 443.93	368.71 ± 244.02	0.19 ± 0.09	0.21 ± 0.09	0.19 ± 0.10

Fig. 23 A & B : Group sizes of different bird species at different times-of-day at *F. benghalensis*

A: (a) Common Green Pigeon; (b) Small Green Barbet; (c) Coppersmith Barbet; (d) Koel; (e) Blossomheaded Parakeet.

B: (a) House Crow; (b) Jungle Crow; (c) Common Myna; (d) Golden Oriole; (e) Tree Pie



A
13
12
11
10
9
8
7
6
5
4
3
2
1
0
a
c
d
e
6.30
7.30
8.30
9.30
10.30
11.30
12.30
13.30
14.30
15.30
16.30
17.30
18.30
Group size
B
12
11
10
9
8
7
6
5
4
3
2
1
0
a
b
c
d
e
6.30
7.30
8.30
9.30
10.30
11.30
12.30
13.30
14.30
15.30
16.30
17.30
18.30
Time of day

daily activity was observed in most bird species as the day progressed. Birds were very active in the morning (6.30 am to 10.30 am) as awell as in the evening sessions (14.30 am to 18-30 am). But were mostly at rest during mid-day time (10-30 am - 14.30 am). The relative abundance of each species differed at different times of day. All common frugivores declined in number as the day progressed (Fig.23). The size of feeding flock was often smallest at mid-day. However, there were slight falls in the number of Parakeets and Koels as the day advanced through mid-day followed by further increase in the evening. Two peaks of abundance were observed in M. virdis, M. haemacephala and T. phoenicoptera (Fig. 23a); a higher one in the morning by 8.30 am and a second peak occurred between 15.30 pm and 17.30 pm.

Among the opportunists, C. macrorhynchos and C. splendens showed similar peaks of abundance (Fig.23b). The first and the morning peak was more pronounced in C. macrorhynchos than in C. splendens. Dendrocitta vagabunda showed slight variation in abundance at different times of day. The Oriole O. oriolus and Myna A. tristis had similar visitation patterns. But in Oriole the peak occurred in the evening while in common Myna it was in the morning (Fig. 23b).

The rates of visitation and feeding, the length of feeding bouts, and pattern of time allocation for foraging, resting, preening etc. showed considerable changes with time of day. The visitation

120.13

Fig. 24. Daily visit pattern of important avian frugivores at *F. benghalensis* at different times-of-day

A: (a) Small Green Barbet; (b) Coppersmith Barbet (c) Koel; (d) Green Pigeon; (e) Blossomheaded Parakeet

B: (a) Jungle Crow; (b) Golden Criole; (c) Common Myna; (d) Tree Pie; (e) House Crow; (f) Greyheaded Myna

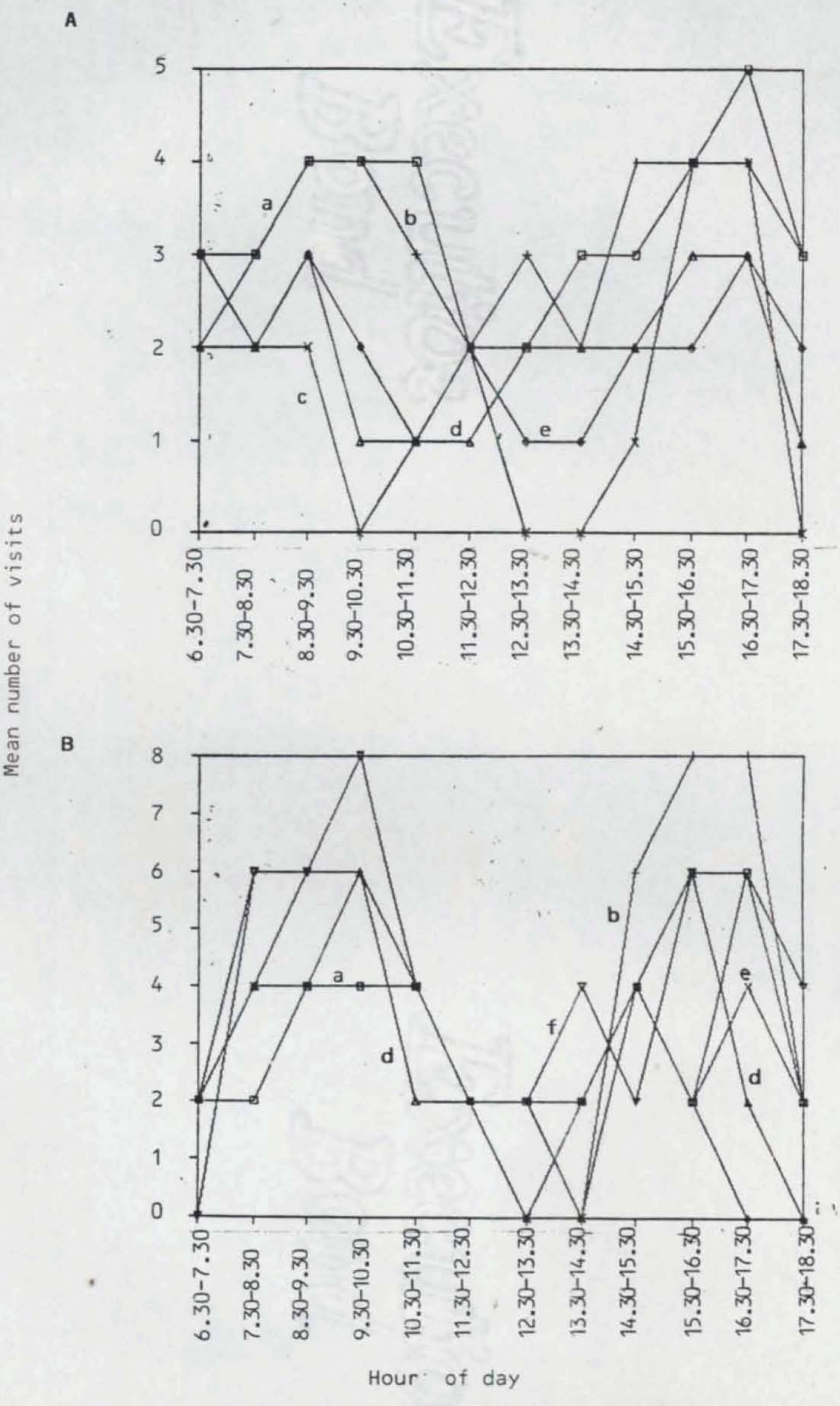

A
B
Mean number of visits
Hour of day
6.30–7.30
7.30–8.30
8.30–9.30
9.30–10.30
10.30–11.30
11.30–12.30
12.30–13.30
13.30–14.30
14.30–15.30
15.30–16.30
16.30–17.30
17.30–18.30
a
b
c
d
e
f

TABLE 40. **Percent time spent in activities at different times of day by (a) ES (b) MV (c) MH (d) TP**
Bird codes as given in table 5. (I) 6.30 - 10.30 (II) 10.30 - 14.30 (III) 14.30 - 18.30

			Perching	Foraging	Flight	Chasing	Oos	Preening	Courtesy	Cleaning	N
(a)	ES	I	41.60±18.08	38.76±17.10	0.04±0.19	6.15±9.31	5.53±8.27	6.63±15.44	0.36±0.94	0.93±0.64	19
		II	49.10±24.26	32.12±24.60	0.04±0.19	6.09±10.69	4.09±8.88	8.21±15.34	- 0 -	0.35±0.52	19
		III	34.73±21.96	50.53±27.09	0.24±0.47	3.66±6.76	3.28±8.14	6.41±13.04	0.42±1.00	0.63±0.71	18
(b)	MV	I	27.17±17.19	58.48±17.86	0.53±0.65	0.27±0.85	8.09±11.42	3.23±7.82	0.17±0.67	2.09±0.89	29
		II	33.26±18.71	48.20±19.27	0.41±0.66	0.47±0.84	8.46±10.64	7.17±12.69	- 0 -	1.53±0.98	28
		III	26.01±15.41	59.57±16.06	0.58±0.82	0.50±0.78	7.28±9.11	4.58±7.03	0.35±0.78	1.03±1.12	16
(c)	MH	I	22.61±15.76	60.24±21.72	0.60±0.74	0.11±0.32	5.06±6.48	10.39±12.81	- 0 -	0.99±0.97	15
		II	27.75±17.89	43.39±30.08	0.75±0.88	0.38±0.70	11.09±9.89	15.23±25.59	- 0 -	1.23±0.93	12
		III	21.23±13.65	64.37±17.87	0.85±0.87	0.46±0.62	5.72±6.63	6.23±10.72	0.43±0.80	0.71±0.78	11
(d)	TP	I	38.34±30.25	47.51±33.11	0.31±0.65	1.24±1.51	5.17±11.19	6.71±15.22	- 0 -	0.69±0.82	20
		II	42.60±28.74	44.59±27.99	0.20±0.51	0.84±0.98	1.88±4.44	9.24±14.59	0.32±0.90	0.34±0.53	15
		III	28.32±23.41	51.50±32.85	0.28±0.58	0.38±0.71	8.04±10.00	10.91±18.74	0.12±0.52	0.52±0.66	20

TABLE 40a. **Effect of time of day on Time budget - One-way ANOVA test**
(Significance level at 0.05)

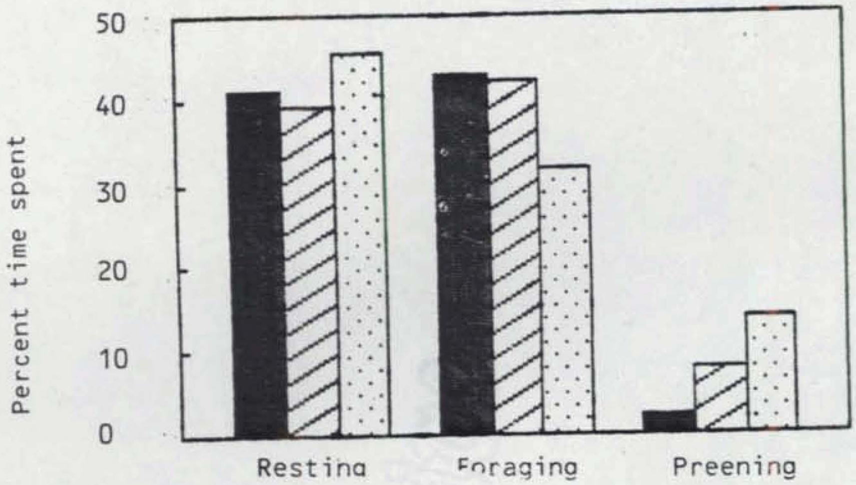
Bird species	DF	F-value	Prob.
E. scolopacea			
I	2	1.42	0.25
II	2	2.26	0.12
III	2	0.10	0.90
M. virdis			
I	2	2.04	0.14
II	2	4.35	0.02
III	2	0.80	0.45
M. haemacephala			
I	2	0.48	0.62
II	2	2.46	0.10
III	2	0.77	0.47
T. phoenicoptera			
I	2	2.09	0.13
II	2	0.80	0.45
III	2	0.07	0.93

(I - 6.30-10.30; II - 10.30-14.30; III - 14.30 - 18.30)

Fig. 25a. Effect of temperature on time spent in major activities by (I) Koel (II) Common Green Pigeon

20-25°C; 25-30°C; 30-35°C

I


50
40
30
20
10
0
Percent time spent
Resting
Foraging
Preening

II

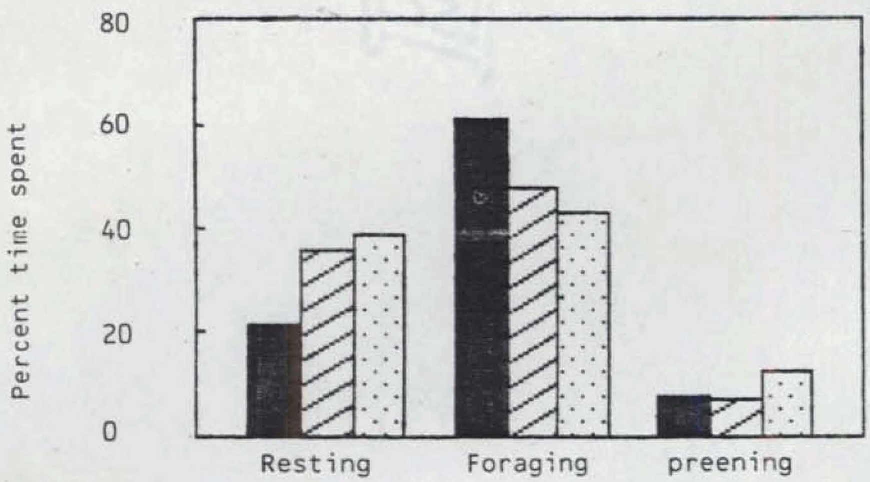
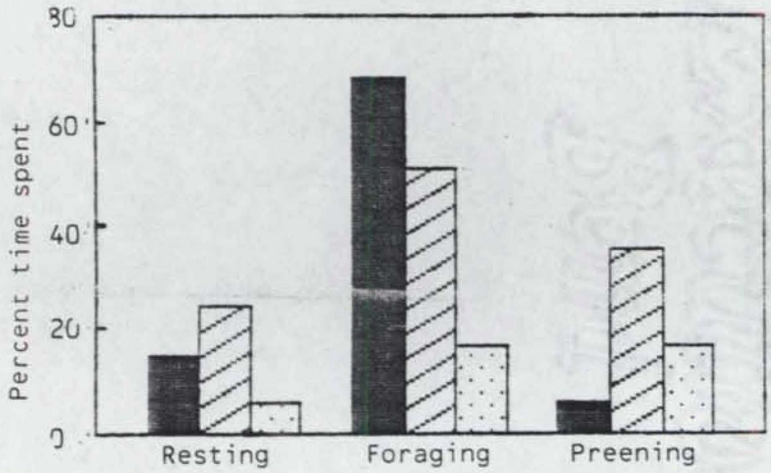

80
60
40
20
0
Percent time spent
Resting
Foraging
preening

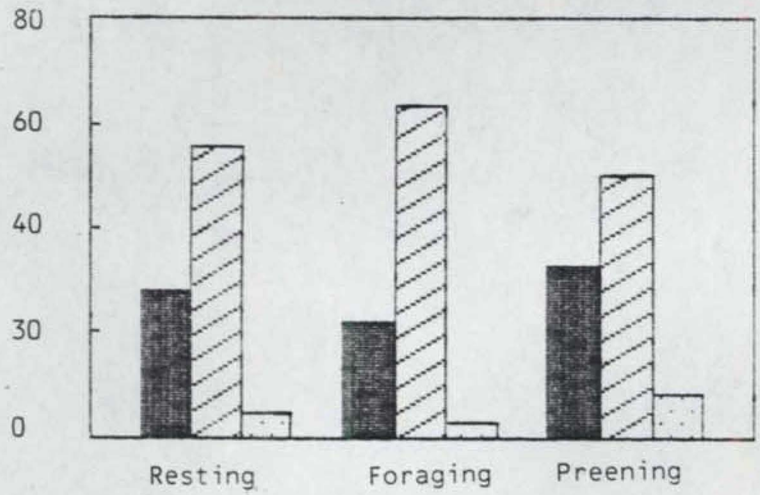
Fig. 25b. Effect of temperature on time spent in major activities by (I) Coppersmith Barbet (II) Small Green Barbet.

$20^{o}C-25^{o}C$; $25^{o}C-30^{o}C$; $30^{o}C-35^{o}C$

I


80
60
40
20
0
Percent time spent
Resting
Foraging
Preening

II


80
60
40
30
0
Resting
Foraging
Preening

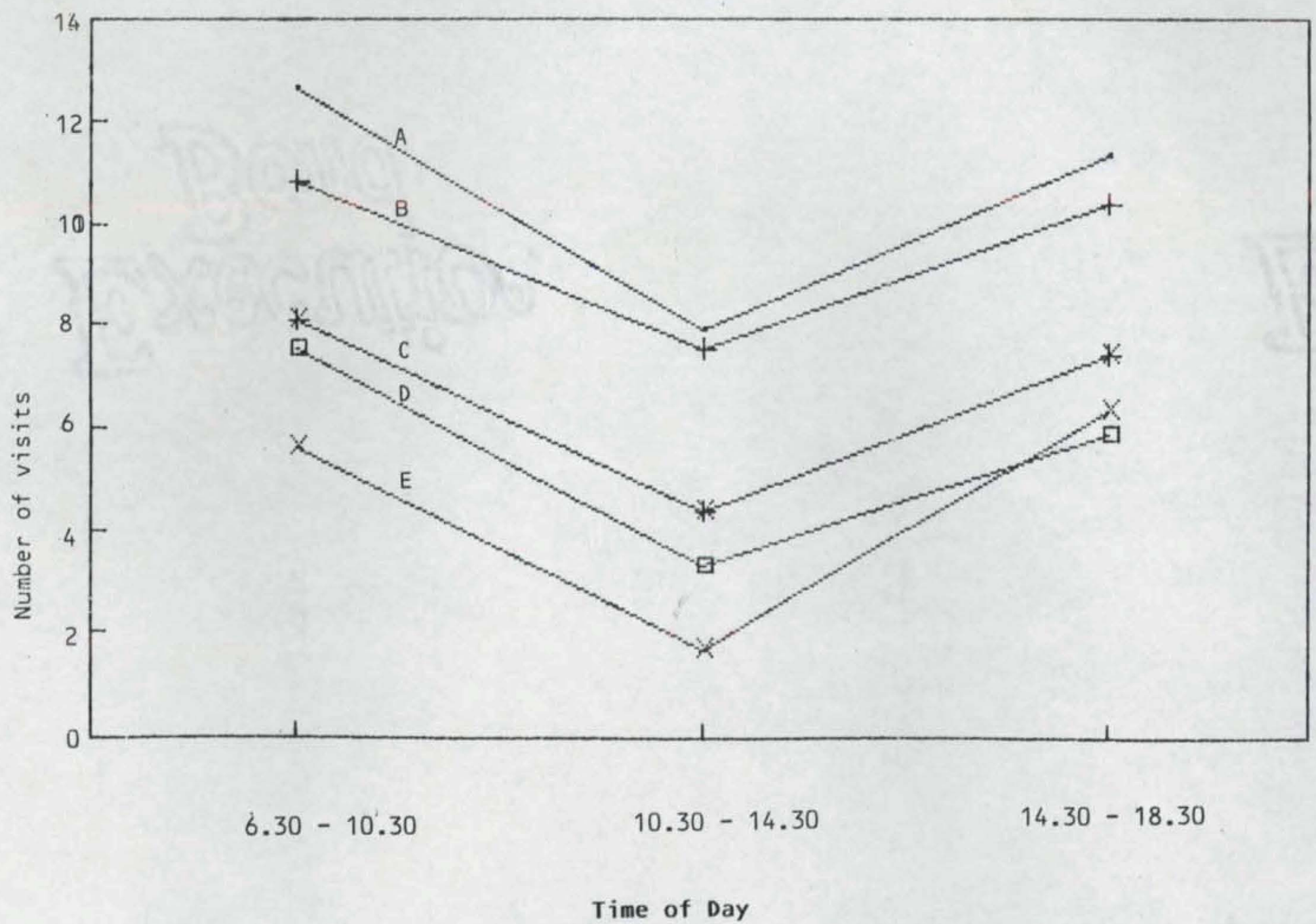
rate declined during mid-day and then increased in the evening. (Fig. 26) There were marked differences in the frequency of visits between morning and mid-day times in M. virdis, M. haemocephala, E. scolopacea, and pigeon T. phoenicoptera (Table 38).

The allocation of time for activities such as foraging, resting (perching) and breeding was modified at different times of day (table 40). Relatively less time was allocated for foraging in the mid-day than either in the morning or evening sessions in Koel, Barbet and Common Green Pigeon (Fig. 25) when the foraging time decreased the resting time increased. The time allocations for preening and cleaning of feathers increased slightly with progress in day time. However no significant variations were observed in the relative apportionment of time for these activities at different times of the day ($P > 0.05$, one-way ANOVA; table 40a).

Temperature

The temperature fluctuations were relatively mild in the Tenhipalam site (between $20^{o}C$ and $35^{o}C$) but were slightly greater in the Vythiri area (between $12^{o}C$ and $33^{o}C$). A study of the effect of temperature fluctuations on foraging activities of four specialised frugivores at Tenhipalam has revealed that there was a general decline in the length of feeding bouts and rate of feeding with

Fig. 26. Influence of time-of-day on frequency of visits on *F. benghalensis* in (A) Koel (B) Small Green Barbet (C) Coppersmith Barbet (D) Common Green Pigeon (E) Jungle Crow



14
12
10
8
6
4
2
0
Number of visits
A
B
C
D
E
6.30 - 10.30
10.30 - 14.30
14.30 - 18.30
Time of Day

TABLE 41. **Percent time spent in activities at different temperatures by (a) ES (b) MV (c) MH (d) TP**
(Codes for birds as in table 5) (I - 20°C - 25°C, II - 25°C - 30°C, III - 30°C - 35°C)

Temp.			Perching	Foraging	Flight	Chasing	Oos	Preening	Courtesy	Cleaning	Total
(a)	ES	I	45.72±18.98	39.41±17.50	0.07±0.24	3.69±4.16	8.54±10.49	1.94±6.73	- 0 -	0.69	12
		II	44.77±17.93	36.65±17.31	-0-	4.58±5.10	5.08±8.28	7.9±16.09	0.11±0.51	0.91±0.77	20
		III	44.12±20.93	33.67±24.73	0.08±0.26	8.05±10.91	4.09±9.27	9.54±16.83	- 0 -	0.45±0.60	35
(b)	MV	I	28.16±20.21	55.62±21.32	0.63±0.62	- 0 -	9.40±14.11	4.42±10.70	0.11±0.38	1.63±1.53	12
		II	21.98±12.49	63.29±15.10	0.44±0.69	0.18±0.69	10.93±16.31	2.73±6.19	0.17±0.58	1.33±1.21	13
		III	32.79±18.37	50.09±15.96	0.41±0.68	0.42±0.74	6.62±9.04	8.23±13.47	- 0 -	1.44±1.09	25
(c)	MH	I	14.75±13.13	67.08±21.34	1.20±1.01	0.30±0.65	9.55±9.35	5.74±9.35	- 0 -	1.16±1.16	10
		II	24.30±13.33	50.75±22.53	0.60±0.65	0.17±0.39	6.75±8.60	16.53±19.08	- 0 -	1.00±0.96	10
		III	34.66±15.88	35.68±22.49	0.67±0.88	0.05±0.12	10.92±12.78	16.94±28.37	0.26±0.98	0.82±0.72	14
(d)	TP	I	24.53±21.66	58.60±26.41	0.27±0.47	0.82±1.55	7.28±12.28	7.52±12.04	- 0 -	0.98±0.83	15
		II	35.69±26.27	47.93±29.79	0.36±0.77	0.47±0.77	7.82±11.8	7.15±15.26	- 0 -	0.56±0.49	13
		III	38.98±23.74	43.15±25.40	0.27±0.58	0.59±0.69	3.87±6.21	12.41±18.63	0.24±0.78	0.49±0.69	20

TABLE 41a. **Influence of temperature on time spent in important activities.**

One-way Analysis of Variance Test (Significance level 0.05)

Activity	DF	F-value	Prob.
M. virdis			
Perching	2	1.53	0.23
Foraging	2	1.70	0.20
Preening	2	0.51	0.61
T. phoenicoptera			
Perching	2	4.23	0.02
Foraging	2	2.93	0.06
Preening	2	0.59	0.56
E. scolopacea			
Perching	2	0.54	0.59
Foraging	2	1.53	0.23
Preening	2	2.03	0.14
M. haemacephala			
Perching	2	2.61	0.12
Foraging	2	3.36	0.08
Preening	2	2.64	0.12

increase in temperature (Table 39). The barbet *M. haemocephala* and the pigeon *T. phoenicoptera* have spent the maximum time per feeding visit at 20^{o}C to 25^{o}C while *M. virdis* and *E. scolopacea* had maximum length of feeding bouts at 25^{o}C to 30^{o}C. There were significant fall in the visitation length of all the four species of birds studied (P > 0.02; ANOVA test). However no significant changes were noted in the feeding rates of these birds with increased temperature (Table 39).

The temperature has also influenced the time budgets of these bird species (Table 41). The foraging time has declined whereas the resting and preening time increased with increase in temperature. The time spent foraging was greatest at 20 to 25^{o} in barbets and fruit pigeon which decreased gradually as temperature increased

Eudynamys scolopacea spent almost similar time in feeding at 20 to 25^{o}C and 25 to 30^{o}C. It declined when the temperature rose to 32^{o}C to 35^{o}C level. Significant variation was observed only in *T. phoenicoptera* (P < 0.02, One-Way ANOVA; table 41a).

Rainfall

Many of the important fruit-eating species such as barbets; fruit Pigeons, Koels, Crows etc. were observed foraging actively in light to moderate rains. But almost all species suspended their

TABLE 42. **Effect of rainfall (moderate) on feeding bouts and feeding rates of four specialist frugivores**

N = Number of samples

Bird spp.	Feeding bout (X) length	Feeding rate (X)	N
E. scolopaeca	273.19 ± 159.85	0.27 ± 0.22	17
M. virdis	266.50 ± 109.42	0.27 ± 0.14	22
M. haemocephala	415.24 ± 185.83	0.13 ± 0.08	21
T. phoenicoptera	318.33 ± 152.88	0.18 ± 0.12	18

activities during heavy rain. The Koel E. scolopacea, barbets M. virdis and M. haemocephala never attempted to eat at heavy rain. The barbets and Koel often took shelter within the foliage canopy. The Koel and the Pigeon flicked up their wings and feathers at times to get rid off the water from the body surface. But all of them continued their foraging activity in light to moderate rains.

The feeding bout lengths showed significant decline with increased rainfall in all the four species of birds (Table 42a, $P < 0.002$ One-Way ANOVA). The feeding rates did not show significant changes in M. haemocephala, T. phoenicoptera and E. scolopacea either at light or moderate rain fall. But there was significant fall in the rate of feeding in M. virdis at moderate rainfall in the present study (Table 42a; $P < 0.01$).

Predation

A feeding assemblage of birds at an aggregate fruit resource was an aggregate resource for raptors. The predation pressure was relatively negligible at Tenhipalam site when compared to that at Vythiri. The Shikra Accipiter badius was the only bird of prey commonly observed at Tenhipalam. They were observed on four occasions attacking birds feeding on figs. Once a Shikra made an unsuccessful attempt at a female Koel in a mixed feeding flock on a

Plate 17. *F. tsjahela* crown:-

a. A male Koel reaching out for a ripe fig.

b. Common Green Pigeon and Koel at rest.

Plate 17

a

b

TABLE 42a. **Statistical analysis for effect of rain on feeding bout length and feeding rate of four important frugivores.**

(FB - Feeding Bout; FR - Feeding rate)
One-way Analysis of Variance (Significance level 0.05)

	DF	F-value	Prob.
E. scolopacea			
FB	1	18.21	< 0.01
FR	1	0.74	0.40
M. virdis			
FB	1	17.44	< 0.001
FR	1	7.02	< 0.02
M. haemacephala			
FB	1	48.03	< 0.001
FR	1	2.15	0.15
T. phoenicoptera			
FB	1	10.85	< 0.003
FR	1	0.03	0.87

fruit-bearing _F. exasperata_. All the foraging birds except one Jungle Crow also flew off immediately.

The Vythiri site had relatively a high density of raptors. The prominent birds of prey observed included the crested Honey Buzzard (_Pernis ptilorhyncus_), the Crested Goshawk (_Accipiter trivirgatus_), the Sparrow Hawk (_Accipiter nisus_) the Crested Hawk eagle, (_Spizaetus cirrhatus_), the Black Eagle (_Ictinaetus malayensis_), the Crested Serpent Eagle (_Spilornis cheela_) Pergrine Falcon (_Falco pergrinus_) etc. The predator threat was so intense that at least one raptor was observed during the period of study. The Crested Serpent Eagle, the Black Eagle, and the Asiatic Sparrow Hawk were the commonest species. The Black Eagles were seen sailing through the sholas or over the canopy searching for prey. Pairs of Crested Serpent Eagle were often seen soaring high in the air. They also used to glide through the foliage canopy and perched on the trunks scanning the surroundings.

The avian frugivores in the area seemed to have adapted to the heavy predation pressure. Unlike their counterparts at predator-scarce Tenhipalam site, the different frugivore species at Vythiri had much shorter feeding bouts. They rarely spent much time resting on the feeding tree and often flew in onto a thick foliage canopy in the neighbourhood after each visit. For example the mean visitation length of _M. virdis_ on _F. amplissima_ in the Tenhipalam site was

TABLE 43. **Aggressive encounters recorded at fig trees at Tenhipalam Site** (Figures are percentages of attacks) - Codes for birds used is as in table 5.

Aggressor	Supplanted species											
	ES	MV	MH	TP	TR	CM	HC	DV	AT	GO	SM	Others
ES	14.13	36.63	22.07	2.50	1.41	0.87	0.54	2.61	0.98	11.20	6.20	0.87
MV	--	56.98	33.52	--	3.35	--	--	--	--	--	--	6.15
MH	--	--	77.92									
TP	0.60	32.34	26.95	22.75	12.57	1.80	--	--	--	--	--	2.99
CM	43.41	9.30	8.53	19.38	--	10.08	0.78	--	--	--	--	3.88

592.72 seconds while individuals of the same species spent only an average 287.90 seconds per visit at the same fig species at Vythiri. Similarly *M. rubricapilla* ($\bar{X}$ 177.17 sec) at Vythiri site also had relatively shorter feeding bouts than its congener *M. haemacephala* ($\bar{X}$ 564.56 sec) at Tenhipalam on *F. amplissima*

The flock feeding behaviour was found to have the advantage of easy predator detection. The conspecific flocks of fruit pigeons often perched atop a more or less leafless tall tree located nearby the fruiting *Ficus*. From this look-out they surveilled the surroundings closely before alighting on the foraging fig. Some members of the flock were always observed to confine their feeding activity at the upper surface of the fig crown- which may be helping them to detect the arrival of predators more easily.

Aggression

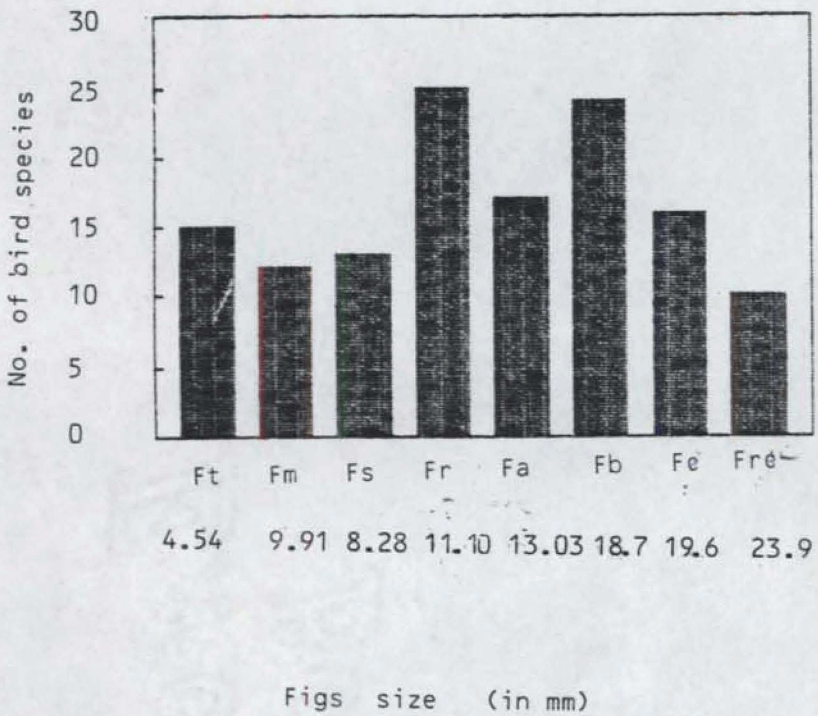
Competition and aggressive interaction among the various avian frugivores seemed to influence their foraging activity. The members in a feeding assemblage competed each other for a common fruit resource. Both intraspecific and interspecific competitions were observed. The fig crop being a superabundant food resource, the aggressive encounters were relatively mild. It was found that the larger and the socially dominant species often displaced or supplanted the smaller and socially subordinate bird species in a foraging tree. Such supplanting attacks occurred among members of the same species also. The Koel, a socially dominant species in the Tenhipalam site, was very aggressive and intolerant towards other species of birds. It maintained feeding territory comprising one or two fig-bearing branches and defended its territory from intruders either conspecific or others. Aggressive encounters involving bill threat, inciting and chases were commonly observed. The Small Green Barbet and the Coppersmith Barbet were found to be major targets of the Koel's attack (Table 43). Over 36% of agonistic encounters of Koel were with the Small Green Barbet and 22% with the Coppersmith Barbet. The former species was the most common competitor of Koel. The two species exploited the most diverse fruit food resources in the Tenhipalam area. The aggressive interactions were less frequent among other bird species. The Small Green Barbets made several intraspecific supplanting attacks. They, however, scared off the Coppersmith Barbets several times while they were pecking at figs. At times, they were observed encroaching the foraging sites of fruit pigeons and Golden Oriole and displaced them. The fruit pigeons were less aggressive and had very few intraspecific and interspecific chases. The major targets of pigeons attack were barbets which often intruded into the former's feeding site. The Jungle Crow used to scare off other smaller foraging bird speacies. They were, specifically, more intolerant and aggressive to Koel than to any other species. Many a time corvids were found deliberately pouncing on Koels even though they had no foraging intentions. Such agonistic encounters were more frequently seen during breeding season. It may be because the Koel is a brood parasite of Crow in this study area. The Coppersmith Barbet and bulbuls engaged mainly in intraspecific encounters (Table 43).

At the Vythiri study area, the aggressive interactions among avian foraging flocks on fruiting figs were relatively negligible. The intraspecific encounters consisting of supplanting chases were observed in barbets, fruit pigeon and bulbuls. The avain fruit-eaters here faced other serious threats like heavy predation by raptors and competition from mammaliam frugivores such as the Bonnet Macaque (*Macaca radiata*), the Nilgiri langur (*Presbytis johni*), the Malabar Giant Sqürrel (*Ratufa indica*) and the fruit-eating bats. Bats were nocturnal visitors to the area.

The Bonnet Macaque was a severe competitor of avian frugivores at most *Ficus* species. One troop of 20 to 25 monkeyswere present in the area. They scared off all the birds and performed voracious feeding bouts often lasting over an hour at the fruiting fig crown. The Giant squirrel usually had no aggressive interaction with birds.

In the Tenhipalam study area the mammalian Competitors at *Ficus* crown included the Palm Squirrel (*Funnambulus palmarum*) and the fruit bat (*Pteropus giganteus*). No agonistic interactions were observed

Fig. 27. Number of bird species attending fig crops of different fig sizes (Tenhipalam Site)


30
25
20
15
10
5
0
No. of bird species
Ft
Fm
Fs
Fr
Fa
Fb
Fe
Fre
4.54
9.91
8.28
11.10
13.03
18.7
19.6
23.9
Figs size (in mm)

between them and birds while foraging. The bats though usually nocturnal in habit were rarely seen foraging on fruiting figs here even at about 4 pm.

Fruit Size

The size of figs was found to affect the efficiency of fig utilisation by various avian visitors. The successful manipulation of fruit was dependent on the morphology of fruits and gape-width of the bird (Wheelwright 1985) No examination of this relationship between gape-width and fruit size was conducted in the present study. The figs being fleshy with several small seeds could be handled successfully by most frugivores irrespective of their bill dimensions and fig size. Several bird species had a piece-meal diet of large figs. The figs of different sizes attracted different sets of frugivores. The medium sized figs of *F. amplissima* and *F. religiosa* attracted the maximum diverse species of birds (Fig. 27). The *F. benghalensis* with slightly larger figs also attracted relatively larger avian assemblage. The fig species with large sized fruits such as *F. racemosa* and *F. beddomei* and those with much smaller fruits like *F. tsjahela* enticed a lower number of avian species (Fig. 27).

ROLE IN SEED DISPERSAL

T. N. Vijayakumar "Resource utilization by birds attending figs in South India"
Thesis. Department of Life Sciences , University of Calicut, 1994

CHAPTER 8

ROLE IN SEED DISPERSAL

The fleshy pulp of fig enclosed a "seed ballast" of several minute seeds. Despite the superabundance of fig seeds, the seedling density at Tenhipalam and Vythiri were relatively very low. This showed that the Fig species encountered high seed and seedling mortalities in both the areas of study. A greater proportion of seeds was dropped beneath the parent tree where they didn't germinate at all.

The present investigation has clearly indicated that the fig seeds had to be housed in a particular mincrohabitat to germinate. The crevices, holes and pockets in branches of trees in the neighbourhood or nearly habitats provided suitable abodes for fig seed development. This called for the necessity of seeds being dispersed by suitable dispersal agents such as birds.

The *Ficus* spp. under present study had either epiphytic or hemiepiphytic growth, particularly during the early periods of development. The species like *F. gibbosa* were mostly epiphytic even in fig-bearing stage. The seedlings of *F. religiosa*, *F. amplissima*, *F. benghalensis*, *F. exasperata*, *F. beddomei* and *F. tsjahela* were seen hemiepiphytically on other tree trunks. Many fig seedlings were developed in the holes and crevices of building walls and fences.

All these clearly indicated the requirement of a vector which could effectively deposit the minute fig seeds in these microhabitats. The avain frugivores which formed a major fig-consumer might also be effective dispersal agents of various *Ficus* species. The minute size of seeds had the advantage of escape from being chewed up or crushed by bird mandibles. They were thus taken undamaged to the intestine and from there to the outside in the faceal package.

The faecal samples of various avain species, both specialist and opportunists examined were found to contain intact seeds. In the present study it was noticed that smaller frugivores like barbets, bulbuls, Myna etc often defaecated one to three times in an active feeding bouts lasting 10 or more minutes. These ground fallen seeds encountered heavy mortality. The larger frugivores such as Koel, Green Pigeon and Crow also defaecated beneath the feeding tree usually but only once in an hour or more.

The faecal samples of fruit pigeons *T. phoenicoptera* and *T. pompadora* collected from ground beneath *F. tsjahela*, *F. exasperata* and *F. benghalensis* contained both crushed and intact seeds. The utilisation of seeds along with the pulp of figs probably provided these fig-specialist with a nutrient rich diet. The results of the present study indicated that the fruit pigeons are partial predators of fig seeds.

The Blossom-headed Parakeet, Rose-ringed Parakeet and Blue-winged Parakeet, chewed up the pulp portion of figs leaving behind scraps of pulp along with the seed mass under the parent tree. Whether they crushed the seeds during chewing or digested them in the intestine could not be studied. They could be considered as "fruit thieves" following the definition of Howe and Estabrook (1977).

The intact seeds from the faecal samples of the Barbet, the Koel, the Green Pigeon and the Jungle Crow were collected. When they were spread on damp filter paper, a greater proportion of seeds germinated in 1 to 2 weeks time.

The results of the present investigation also showed that the fruit-eating specialists, mainly barbets, Koel, and Green Pigeon, owing to their greater dependence on Ficus fruits were more important than the opportunistic frugivores as dispersal agents. However, the opportunists were also true or 'leagitimate' dispersers of figs since they voided many undamaged seeds in their faecal deposits.

DISCUSSION

T. N. Vijayakumar "Resource utilization by birds attending figs in South India"
Thesis. Department of Life Sciences , University of Calicut, 1994

CHAPTER 9

D I S C U S S I O N

(i) Fruiting Phenology

A variety of sizes, shapes, colours and textures were observed among figs of various *Ficus* species of the areas of present study. According to Janzen (1979) this variety was adaptive in moulding the dispersal coterie.

The present study on the fruiting patterns of nine species of *Ficus* showed that the flower initiation and fruit prodction occurred in the fig community almost throughout the year. In a review of *Ficus* ecology, Janzen (1979) suggested that members of particular species initiated flowering randomly with respect to time and season.

In the Tenhipalam site the populations of *F. benghalensis* and *F. exasperata* with over 15 members in each, had ripe figs for 20 and 16 months respectively during the 24 months of study between 1990-92. *F. racemosa* trees presented figs in 21 of 24 months while *F. religiosa* (6 trees) bore figs for 18 months and *F. tsjahela* (2 trees) had fruition for 16 of the 24 months.

Similarly in the Vythiri site, members of 5 species of *Ficus* had figs for most of the time in an year. *F. tsjahela* had atleast one member with ripe figs in 21 out of 24 months; *F. beddomei* and *F. microcarpa* could produce ripe figs for 19 months each; the members of *F. exasperata* bore fruits for 18 months and *F. amplissima* had 1 tree in fruits for 16 of the 24 months. Corlett (1987) had observed such a longer period of production of figs in *F. fistulosa* in Barro colarado-island, Panama.

The number of crops per year in a particualr tree had varied from species to species. The *F. racemosa* produced 5 to 6 crops, *F. racemosa* produced 5 to 6 crops, *F. religiosa* and *F. microcarpa* produced 2 to 3 crops, while the *F. tsjahela* bore 3 to 4 crops in an year. Abdurahman and Joseph (1976) had noted production of 6 crops in *F. hispida* Linn. in Calicut. Hill (1967) had reported the presence of 3 to 4 crops in *F. microcarpa* var. *microcarpa* in Hong Kong. He has also recorded 5 crops in *F. elastica*.

A high degree of intra-tree synchrony in fruit maturation was observed in all the nine *Ficus* species studied whereas the degree of inter-tree and intra-specific synchronisation was rather low. Bonaccorso (1975) and Morrison (1975) stressed the highly synchronised intra-crown ripening period for fig in Barro colorado island. A similar intra-tree synchronisation and inter-tree asynchronization of fruiting had been discussed by Hill (1967); Ramirez (1970); Jazen (1979); Milton et al. (1982); Morton et al. (1982) and Corlett (1987). The intra-tree synchronization was, presumably, advantageous to the plant since it attracted a good assemblage of dispersal agents. Corlett (1987) made a similar observation in F. fistulosa.

According to Milton et al. (1982) the greater number of crops per tree and the lesser inter-tree synchronization might result from the absence of a cold winter, within a species the number of crops per tree seemed likely to be greater in climates that are favourable for fig production all the year.

The unusual intraspecific asynchrony in fruiting of F. yoponensis and F. inspidia in Barro colorado island, resulted from each trees fruiting at intervals which averaged slightly less than a half year or less than a full year respectively (Milton et al., 1982). In the Ficus species of present study, the fruiting intervals were slightly less than a half-year for F. benghalensis, F. religiosa and slightly less than one year in F. amplissima, F. exasperata and F. beddomei. According to Mitton et al. (1982) two major selection pressures namely; (i) the pressure to maximise pollination (both with respect to seed-set and pollen-dispersed) and (ii) seed dispersal; operated on individuals of most tree species.

Ramirez (1970) and Janzen (1979) found that this unusual fruiting patterns of members of the genus Ficus were because of pollination of each species by an obligate host-specific wasp species. In the present study, an obvious advantage of such an asynchronous interplant fruit production was the increased chance of seed dispersal. Each plant fruiting at different times could ensure a larger assemblage of frugivore and thereby avoid or lessen the intensity of intraspecific competition between plants for dispersal agents. / A similar observation was made earlier by Milton et al. (1982) in F. yoponensis and F. incipida. In addition to the agaonid wasp pollinators, the Ficus species seemed to have ties with certain dispersal agents, particularly vertebrates like fruit pigeons and fruit bats in the areas of present study. A similar relationship has been found between figs and howler monkeys and fruit bats in Barro colorado (Milton, 1980, 1981).

Despite their unusual inter-tree asynchronization in fruit production, some members of the population did present ripe figs more or less simultaneously during certain times of the year. A period of peak fruit production was then observed in many species. In the Tenhipalam site, F. benghalensis had three trees in ripe fruition during January through March 1991; F. exasperata hao eight trees in fruition during March 1991 and ten trees in April 1992. In the Vythiri study area, the peak periods of ripe fig production were

December for F. amplissima (five trees), March for F. beddomei (eight to ten trees) and May for F. exasperata (seven to ten plants) in both the year of study during 1990-92.

Milton et al. (1982) observed a bimodally distributed peaks in F. yoponensis and F. insipida with 2 peaks in an year. The occurrence of such peak fruiting periods could be explained by assuming that inaddition to their pollination specificity and dispersal dependence in flowering and fruiting the fig trees utilised and responded to the environmental cues to initiate fruiting at certain times of the year. According to Milton et al. (1982) any member of the population with sufficient reproductive reserves accumulated and produced fruits at these times.

Milton et al. (1982) observed a temporal displacement between species with respect to the time of peak fruiting. According to him this represented a competitive displacement and minimized the interspecific competition for seed dispersal agents. A similar observation has been made in the present study. The peak fruit ripening in F. benghalensis occurred between December and March while in F. exasperata it occurred from March through May.

One species of Ficus in the present study viz., F. microcarpa was found to abort a greater proportion of its crop at young stage itself. Janzen (1979) explained such an abortion of young figs as owing to failure of pollination. The unpollinated and seed-sterile figs were dropped from the plant. Galil (1973) observed such a phenomenon in F. religiosa and it was attributed to the non-carriage of pollen by the incoming agaonids (Blastophyga quadraticeps) and failing to effect pollination but only to oviposit and rendering the fruits sterile. Hill (1967) has observed the abortion of figs in F. elastica for lack of proper pollinators resulting in cessation of further development of syconia. The incidence of aborted fruiting was also correlated with the presence of incompetent insects other than fig wasps whose larvae develop inside the figs (Janzen, 1979). The present study has revealed that in F. microcarpa the abortion of young figs was due to the failure of pollination. It was the lack of sufficient number of pollinator wasps which might have caused the fig abortion in these figs (Priyadarsan; Pers. communication).

b. Avian Frugivore Assemblage and Daily Activity

The avian fig consumer assemblage was among the most diverse reported for tropical trees with regard to tree species and taxonomic affinities (Jordano, 1983). Such large asemblages of avian frugivores on figs had been described by Janzen (1983), Beehler (1983), Breitwisch (1989) and Lambert (1989). Similar large and diverse assemblage of birds consisting of major furit-eating species and several insectivores which used fruits as occasional food source were observed attending figs in the present study. The robust stems with sessile and subsessile or pedunculate figs allowed both small and large potential dispersers to have access to the fruit by a variety of foraging behaviours. The succulent, fleshy figs were exploited by the smallest Tickell's Flowerpecker to the larger Crow, Imperial Pigeon and Hornbill. While species like fruit pigeons, barbets and koel were regularly visiting the fruiting crowns of _Ficus_ and consumed large quantities of figs, others like Shrikes, babblers, Chloropsis, Magpie Robin etc. were very infrequent visitors.

The colours exhibited by figs with a predominance of red, yellow, purple or pink tones were typical of fruits which attracted birds (Ridley 1930; Corner 1949; Turcerk 1963; Vander Pijl 1969; Janzen 1983; Knight and Siegfred 1983; Wheelwright et al. 1984) although these bright colours are attractive to primates (Gautier-Hion et al. 1985) However, nearly 20% (4 species) of the bird dispersed _Ficus_ taxa in the present investigation possessed dull coloured ripe figs. Lambert (1989) recorded 13.5% of the bird dispersed _Ficus_ species at kualalompat with dull ripe figs while only 6 of the 140 bird dispersed _Ficus_ species in a Costa Rican forest had brown or green fruits (wheelwright, 1984). Fleming (1979) and Gautier - Hion et al. (1985) suggested that the fleshy dull fruits (especially green coloured) are favoured by bats. Lambert (1989) had recorded some of the largest aggregations of fruit-eating birds on the four *Ficus* species with dull coloured figs. In the present study similar large aggregations of frugivores were observed in *F. amplissima* and *F. tsjahela* trees with dull coloured figs. The superabundant crop characterising the *Ficus* species, or their nutritional rewards or other traits might have enticed these avian frugivores. According to Morrison (1978) figs probably represented a readily utilisable source of calories and water (0.5 kcal and 0.40 gm water per fruit) but failed to provide a balanced diet to frugivores feeding on them. The fig eating species in the present study included birds with exclusively phytophagous (*Treron* pigeon) and virtually insectivorous diets (Magpie robin). Altogether in the two study areas a total of fifty bird species were found feeding on various fig crops. The assemblage of frugivores were divided into 2 categories, namely, the "specialised fruigivores" and the "opportunistic frugivores" (Mckey, 1975; Snow 1971; Howe and Estabrook, 1977). The opportunists were prominent insectivores which haunted the fruiting trees occasionally or at seasons of insect scarcity.

This study showed that the specialist frugivores such as *E. scolopacea*, *M. virdis*, *M. haemacephala* and fruit pigeons, *T. phoenicoptera*, *T. pompadora* were the most important fig consumers. The parakeets, *P. cyanocephala* and *P. krameri* at Tenhipalam and *P. columboides*, the Hornbill, *T. griseus* and Imperial Pigeon *D. badia* at Vythiri were only infrequently visiting the fruiting crowns of *Ficus*.

The role of figs in the diet of different bird species varied considerably. A close association was found between certain bird species and *Ficus* species in both the areas of present study. The fruit pigeons *T. phoenicoptera*, *T. pompadora* and the barbets *M. haemacephala* and *M. rubricapilla* had a greater dependence on figs. The Koel, *E. scolopacea* and barbet *M. virdis* were also seen widely utilising this fruit resource. These two species of birds were quite common at fruiting *Ficus* plants and usually had relatively longer feeding bouts. The parakeets were observed to be less significant fig-eaters in the present study. But Sorensen (1983) in her brief report on frugivorous birds of South India had considered them very important with *Ficus*

The bulbuls *P. cafer*, *P. jocosus*, *H. madagascariensis* and *H. indicus* are also principally fruit-eating birds (Ali 1969) and are considered as specialised frugivores. However, they were not much dependent on figs in this study. At Vythiri site the bulbuls *P. jocosus* were more frequently visiting figs at lower elevations while the bulbuls *H. madagascariensis* were more commonly seen at higher elevations (> 1000 m) and they visited the figs at these altitudes.

Certain opportunistic frugivore species seemed to have a closer association with some of the fig species. The Corvids _C. macrorhyncos_ and _C. splendens_ were having greater dependence on _F. benghalensis_, _F. racemosa_ and _F. religiosa_ than other _Ficus_ species in the Tenjhipalam study area. The oriole _O. oriolus_ was more frequent at _F. religiosa_ and _F. tsjahela_. Such closer associations between birds and figs were described by Mackworth-Bred and Grant (1973), Rudran (1978), Cords (1987) and Lambert (1989).

This study showed that the specialized frugivores ate more than three-fourth of the fig crops removed per day. According to Flemming et al. (1972) and Morrison (1978) individual trees widely dispersed in their habitats and asynchronous in their fruiting, probably, interacted with different sets of consumers. Gautier-Hion et al. (1989) considered figs as an unpredictable resource always produced by a few trees that are widely scattered. The figs in Makoku forest were infrequently and opportunistically eaten in small amounts by frugivorous birds and mammals except bats. "Reliance on such food patches required that a species be able to forage very widely." Figs are expected to be important only for a few "nomadic" species (Gautier-Hion et al., 1989). Similar findings were made by Ershad (reviewed by Gautier-Hion et al., 1989).

However the results of present study indicated that, apart from the so-called "nomadic" or widely foraging green pigeons T. phonicoptera and T. pompadora several resident and local migrant species of birds such as E. scolopacea, M. virdis, M. haemacephala, M. rubricapilla, C. macrophyncos etc. were consistant visitors on fruiting figs. The Ficus here provided a more or less regular and more predictable supply of figs to the frugivores. One probable reason for such an important role of figs in the diet of different avian frugivores, might be the greater representation of figs in the present areas of study. The Ficus populations here contained members in fruiting during most time of the year. The figs in Makoku forest had a very poor representation (Gautier-Hion et al., 1989).

The remarkably differential feeding rates of various bird species indicated that the relationship between abundance and availability is different for different species of visitors (reviewed by Charnov et al., 1976), a phenomenon often neglected by modellers of foraging strategies but of demonstrated importance in other coevolutionary contexts (reviewed by Heinrich, 1975). According to Howe (1977), in a coevolutionary system other things being equal, high rates of successful feeding might indicate interdependence. Similarly in the present study high rates of successful feeding were observed in specialised frugivores, particularly fruit pigeons, barbets, koel etc. which had a greater dependence on figs. However there was little variation in the visitation pattern and feeding rates among congeneric and confamilial species. Similar observations were made by Breitwisch (1983).

Definite strategies concerning behavioural patterns and feeding techniques were adopted by various species of birds while sharing a common resource to avoid or minimise the intra- or interspecific competitions and to achieve maximum resource exploitation and also to escape predation. Considerable variations were seen in the deployment and use of these foraging modes. The widely foraging and sit-and-wait foraging modes were the two commonly used tactics of fruit search. The 'widely foraging' mode is characterised by several short moves and high move rates while the sit-and-wait mode involved long moves and low move rates (Williamson, 1971; Eckhardt, 1979; Landres and MacMahon, 1980, Paskowski, 1982). The relatively sedentary and aggregated food sources favoured 'widely foraging' (Smith, 1974a). The use of sit-and-wait strategy has been correlated with non-aggregate food sources (Huey and Piyanka, 1981). In the present investigation also such 'widely foraging' behaviour patterns characterised by a high rate of short hoping movements were come acoss in barbets, mynas, bulbuls, flowerpeckers, white eye etc. They also undertook diagonal flights far and across the fig canopy in search of ripe figs. Whereas the fruit pigeons, Koel, Hornbill, Blue Bird, Black Bird etc. usually adopted a sit-and-wait mode of food search making relatively fewer and longer movements. However during intensive feeding activities, particularly in the morning and evening bouts the fruit pigeons performed several short 'hops' and 'walks' and some 'flights' also across the fig canopy.

The sit-and-wait mode of foraging might be a conservative strategy accepted by large frugivores to save energy, particularly on less nutritious fruit. This feeding tactics was characteristic of insectivores which has a non-aggregate and moving food source. The opportunistic frugivores, which are prominently insectivorous, widely used the same strategy while feeding on fruits (Verbeek, 1975; Eckhardt, 1979; Landres and MacMahon, 1980). The large Cuckoo Shrike, Golden Oriole, Black-headed Oriole and Tree Pie all of which were opportunistically eating figs employed both the 'widely foraging' and the 'sit-and-wait' mode of food search.

The Koel, the Hornbill and the Imperial Pigeon were usually selective in feeding. They found out the ripe figs and plucked them. The Koel and the Malabar Grey Hornbill were observed selectively picking up the fully ripe scarlet coloured figs of F. exasperata. Breitwisch (1983) had reported such selective feeding of ripe fruits by piping hornbills (Bycanistes fistulator) in a Southern Cameroon tropical wet forest.

The use of different feeding techniques was dependent on the morphological features of both the fruiting plants and the foraging species. The fig-display pattern, the fruit size, fruiting time etc. influenced the avian foraging patterns. The diametre of the figs studied ranged from 4 mm (F. tsjahela) to 30 mm (F. beddomei). Similarly the figs were displayed in a variety of spatial patterns like the terminal clusters in F. amplissima or F. benghalensis, the cauliflorous pattern as in F. tsjahela. In F. racemosa the figs were borne directly on branches and trunks of the tree.

There were considerable variations in the fig-manoeuvring techniques by different species of birds. The Koel, the Small Green Barbet, the Imperial Pigeon and the Hornbill often plucked the figs from a perch and swallowed them in whole. But the larger figs of F. benghalensis, F. exasperata and F. racemosa were taken in by the Koel and the Barbet only with a brief mandibulation by bill. The fruit pigeon, Coppersmith Barbet, Parakeets, bulbuls, Myna etc. had a piece-meal diet of large figs. The smaller figs like that of F. religiosa, F. amplissima and F. tsjahela were swallowed by most bird species. Similar feeding patterns had been observed in neotropical frugivores, the contigids and manakins (Snow, 1976), and in Paradisiades (Beehler, 1983). The crow and Tree Pie move over to a neighbouring perch usually on the same tree after picking up figs and ate bit-by-bit holding them with claws. Kantak (1979) had observed similar feeding behaviour in corvids and Icterids. Aerial feeding or 'sally foraging' tactics observed largely with the Large Cuckoo

Shrike and the Blue Bird in the present study had been reported as a common strategy of food getting in bulbuls by Seveinghans (1978). The bulbuls, Orioles and very occasionally Crow and the Tree Pie were also seen picking up figs in flight (Table 36). Similar foraging patterns were observed in Muscicapids (Herrera and Jordano, 1982), in Quetzals (Santana et al. 1984) in tits (Sorensen, 1983) and in the White-cheeked Bulbul (Khalid et al. 1986). The use of different foraging patterns by different species of birds was of advantage to them to reduce the severity of competition and also to bring out effective sharing of crop among them.

Resource partitioning is characteristic of frugivory (Howe, 1977). According to Charnov et al. (1977) the variation in feeding techniques of different species of birds might result in some fruit species more accessible to certain bird species than others, birds preferably feeding upon those species of fruit on which they are more adept.

In the present study a vertical segregation of foraging sites into upper branch, middle branch and lower branch was conspicuous in many bird species. The Fruit pigeons and the Copper-smith Barbet used the three different sites in the order, upper branch > mid-branch > Lower branch. The small Green Barbet utilised all the three sites with more or less equal ease. However, they were more active on the mid-and lower branches like Koel (Table 34). "Sally foraging" species such as Shrikes and Blue bird, preferred the lower branches. The more complex and anastamosed branching pattern atop was likely to be disadvantageous to aerial feeding. A similar finding has been reported by Santana et al. (1984) in Quetzals (Trogonidae) which are also efficient aerial foragers.

The foraging activity of aivan frugivores lasted throughout the day. Nevertheless, factors such as weather like time of day, temperature, and rain falls, morphological features of figs, time of fruiting and interaction between different bird species, predation etc. affected the intensity of feeding. A decline in relative abuandance and intensity of foraging activity was observed in most species as the day advanced. Howe (1977) observed similar visit pattern and resource depletion in Caesaria corymbosa by the avian frugivores in Costa Rican rain forest. A bimodally distributed feeding activity was observed in many species in present study. There were two peaks of activity, one during the morning session and another in the evening time, with a precipitous drop by noon or mid-day time (Fig. 23, 24). The fruit pigeon had three major meals per day, namely morning, noon and evening meals. Breitwisch (1983) had described similar visitation pattern of birds at fig tree in a Southern Cameroon Tropical wet forest. Hartely (1964) had reported such a foraging pattern in berry-eating thrushes. The barbets M. haemacephala, M. rubricapilla, M. virdis and bulbuls P. cafer, P.

jocosus and H. madagascariensis in this study foraged almost steadily throughout the day. Muthukrishnan et al. (1981) observed similar foraging behaviour in M. haemacephala.

The variation in visitation pattern and feeding activity might have also been due to increased temperature as the day progressed. Minimum activities were observed in Koel, Barbet and Green Pigeon at mid day time when the temperature was recorded maximum. Brown Smith (1977) had noticed the adverse effect of temperature change in the feeding rate of starlings. The rainfall also influenced the foraging activity rather adversely. Though most bird species continued feeding in light to moderate rain, none were observed active in heavy rain.

The role of fruit size as a limiting factor in resource utilisation by avian frugivores has been discussed by many authors (Terborgh and Diamond 1970; Diamond 1973; Snow 1973; Wheelwright 1985). In the present investigation, the medium or moderate sized fig-bearing Ficus species such as F. amplissima and F. religiosa were seen attracting the maximum number of bird species (Fig. 27). Kantak (1979) and Wheelwright (1985) had made similar findings. However, larger ripe figs of many Ficus species being very fleshy with much smaller seeds could be devoured successfully by a greater number of avian species than any other berries with large seeds. The persistence of ripe fruits on the tree also influences their efficient utilisation by many frugivores. The ripe figs of _F. racemosa_ and _F. beddomei_ due to their poor persistence ability could not be effectively handled by avian foragers most of which had a piecemeal diet of these large sized figs.

The spatial and display patterns of fruits in the tree also affected resource utilisation. The importance of fruiting displays had been discussed by Howe (1977) and Kantak (1979). Figs toward the tip of pendant branches called for dexterous manoeuvring techniques from the visitors. The larger bird species such as Green Pigeon, Koel, Crow, Tree Pie etc., found it more difficult to pluck figs that were borne on drooping branches in _F. tsjahela_, _F. religiosa_, _F. amplissima_, etc. The Green Pigeon often leaned down from a perch and tried to pick up these figs and the Koel used a 'hanging down' position with moderate success. The Crow and Tree Pie attempted to get at these figs while on flight. Similarly, the spatial arrangement of figs directly on larger branches and trunks in _F. racemosa_ made foraging activity more laboursome for most frugivores.

Interspecific and intraspecific aggressions including territoriality were observed among various avian frugivores, particularly at Tenjhipalam site in the present study. Howe (1977) had described the occurrence of such interactions and behavioural patterns among frugivores. According to him frequent intraspecific and interspecific agression, including territoriality within tree crowns and virtually identical use patterns suggest severe competition. There was a general view that birds compete for fruits only during times of scarcity (Leck 1970; Fleming, 1979; Foster, 1982b). However, the fig crops in this study were superabundant resources and the intraspecific and the interspecific competitions were generally less severe. This agrees with the findings of Leck (1970), who suggested that at superabundant resources, the competition, intraspecific or interspecific was negligible. But from June through September there was a general scarcity in fruit food availability at Tenhipalam. Then the competition and aggressive interactions in the avian frugivore community, especially between the Koel and others, gained momentum. Usually such aggressions involved supplanting chases in which a larger or socially dominant species displaced a subordinate species. The Koel and Crows were the important socially dominant species at Site-1 and they often scared off others. Among smaller bird species such as barbets and bulbuls competitions were mostly intraspecific. Breitwisch (1983) had observed less severe intraspecific aggression in frugivores at a fruiting _Ficus_ sp. vine in a south cameroon tropical wet forest.

An unusual aggressive interaction was observed between Koel and Jungle Crow. The Crow usually dominated the Koel and was found to be highly intolerant of the latter. On three occassions during this study, the crows were seen, deliberately pouncing on Koels and pursued them for 25 to 50 m distance from the foraging fig tree. It seemed to be because the Koel is a brood parasite of Crow in the study area.

Similarly it was found that the Koels were more aggressive to barbets, more specifically to the Small Green Barbet (M. virdis). The latter had almost similar foraging patterns as that of former species. It was more potential competitor of Koel at most fruiting trees at Tenjhipalam than any other avian frugivore (Vijayakumar et al., 1993). Such an agonistic behaviour in defense of fruit has been studied in mistle thrushes Turdus viscivorous (Snow and Snow, 1984). It was also observed in the present investigation that some of the smaller resident frugivores like barbets successfully scared off even larger foragers such as Golden Oriole. The Small Green Barbet, occassionally encroached the foraging sites of Treron pigeon and displaced them. The Oriole was a migrant while the pigeons were nomadic species. Leck (1972) suggested that in aggressive encounters at food source the migrants were usually subordinate to the residents.

The bird species like E. scolopacea exhibited territoriality which effectively defended and maintained feeding territories in a fruiting fig. It had the advantage of ensuring a steady supply of fruit resource. This species was often very aggressive and intolerant towards intruders either conspecific or others. Individuals of fruit pigeon *Treron* species was found to forage on the same branch but spatial separation was maintained among them for most part of the day. However, they were less aggressive than Koel to the intruders. Similar maintenance and defence of feeding territories in frugvores were described by Moore (1978) and Snow and Snow (1984). The benefits of territorial behaviour came from the acqusition of resources that other individuals might harvest if the territorial behaviour did not; the costs of territorial behaviour are those involved in keeping these competitors away. As long as the cost of defense is less than the resource reward, territorial reward is adaptive (Brown, 1964).

Either inter- and intraspecific ineractions were relatively negligible among avian frugivores in the Vythiri site. Here the bird species encountered two other major threats, viz; (i) the competition from mammalian frugivores and (ii) the threat of predation by birds of prey. The Bonnet Macaque (*Macaca radiata*) and the Malabar Giant Squirrel (*Ratufa indica*) were the important mammalian competitors of birds at figs. The giant squirrel had no aggressive interaction with the bird species while the monkeys whenever visited scared off the avian visitors from the crown of fruiting *Ficus*.

Predation by raptors was the most important concern of avian frugivores at Vythiri site. According to Beehler (1983) the fear of predation might be one of the forces modifying fruit-foraging behaviour in birds. To overcome this threat, various frugivores have adopted various defensive or protective measures. The fruiting fig crowns were usually either leafless or thinly foliated and hence provided little hiding facilities to the foraging species. Therefore most of the foraging species, here had much shorter feeding visits relative to their counterparts in the other study area, where predation was negligible. The foragers often flew on to a neighbouriing perch tree after each visit to return to the feeding tree in a few or more minutes. Similar behavioural adjustments were observed in *Tityra semifuscata* (Howe 1979) and paradisieds (Beehler 1983). The cryptic colouration of body as was seen in green pigeons and barbets was also adaptive since it made prey-detection difficult to predators.

The group foraging or social foraging is another important attribute of frugivory. The degree of sociality in foraging, however, varied among bird species. The abundant crop of figs could attract large conspecific and mixed flocks. Most bird species foraged in groups of two or more numbers. Larger and most commonly observed flocks were those of fruit pigeons *T. phoenicoptera* and *T.pompadora*. Barbets, White Eye, bulbuls and Grey-headed Myna also formed moderate to relatively large conspecific feeding flocks. According to Faaborg et al. (1988) the group foraging has both resource and antipredator advantages. The detection and utilisation of patchily distributed resources were better in foraging flocks. Vigilance increased with increasing group size; making each individual both safer and better able to feed. It appeared that individuals of some species such as fruit pigeons (Treron sp.) served as sentinals which gave warning cues to its flockmates to escape predation. The flock of pigeons usually alighted on the top of tall, often bare or thinly leafed tree nearby the fruiting fig. From this vantage point they scanned the surrounding area, probably for assessing the presence or approach of a raptor and also assessed the potential competitors at the fruting plant. It was found that some of the pigeons in the flock often foraged atop while others used to forage on the lower branches.

Some of the birds species in the mixed flock even mobbed at a predator and scared it off. For example the Jungle Crow and the Black Drongo (Dicrurus adsimilis) were seen, at times, chasing off the Shikra (Accipiter badius). Similar observations on benefits of mixed feeding flocks were made by Vijayan (1984, 1988).

The fruit pigeons, barbets and Koel were seen shunting between two or more fruiting trees of the same species or of different species. For example the pigeon T. phoenicoptera and barbet M.virdis were seen making such feeding visits between Bridelia retusa and F. benghalensis. This foraging pattern of the avian frugivores was similar to the 'trap-lining' behaviour described by Janzen (1971), Stile (1975), Howe and Primack (1975), and Howe (1977).

Studies on the time budgets ie; allocation of time for different activities were carried out in the present study. The use of time budget analysis derives from an assumption of foraging theory, that net energy yield from feeding increases concomittantly with an increase in time spent feeding (Schoener, 1971). Information on approtionment of time for maintenance and feeding activities is important for understanding the evolution of foraging and reproductive behaviour (eg. Verner 1965; Stiles, 1971; Verbeek, 1972; Schemske, 1974). The smaller bird species like barbets spent more time for feeding than for other activities. The greater feeding time of barbets and other smaller frugivores was, probably that increased accessory flight time and their frenetic movements while foraging would require increased feeding time to maintain energy balance. similar findings were made by schemske (1974) in nectar feeding humming birds. According to him at non-limited food resources, the feeding time may be a function of time spent in energetically expensive activities. Usually larger bird species like Koel spent more time at rest than at foraging. Resting can either be a way of conserving energy (cf. Magrath and Lill, 1983; Reebs, 1986) or a buffer in the time budget, if the demand on another activity should increase (Enoksson, 1990). The Koel which maintained feeding territories allocated greater proportion of time in defense of territory and in agggressive interactions than other species of birds. Schemske (1975) suggested that birds that maintain feeding territories exclusive of the breeding season often utilised resources relatively stable in time and space. The time of day and temperature influenced the daily activity patterns of birds (Estes et al. 1986; Paulus, 1988; Enoksson, 1990). Similar findings were made in the present study in Koel, Barbet and Common Green Pigeon. The time spent feeding declined with increased temperature and with progress in time-of-day. The effects of different temperatures were less severe in the present study since the fluctuations in temperature were relatively mild. Similar observations were made by Enoksson (1990) in nuthatches *Sitta europaea*. The effects of both temperature and time-of-day could not be distinguished clearly from each other in this study. The temperature was maximum at mid-day when avian visitors were mostly at rest and at preening activities. Greater proportions of time were spent feeding in the morning and evening than in the mid-day. Similar observations were made by Paulus (1988) in Mottle ducks and Enoksson (1990) in nuthatches *Sitta europaea*. At high temperature it might have been energetically advantageous to reduce feeding while low temperature increase the energy requirements for maintenance (e.g.; Bryant and Tatner, 1988; Paulus, 1988). Caraco (1979) found that the yellow-eyed Junco (*Junco phaeonotus*) a small passerine bird, spent more time foraging at lower environmental temperatures.

c. Role of Frugivores in Dispersal

The minute seeds of *Ficus* species required the service of dispersal agents for their propagation. The avian frugivory as a means of seed dispersal seemed extremely important for the plant's survival. The fig seeds could find their way through the gut of most frugivore species without much damage and germinated into viable seedlings. The results of the present study indicated that due to their greater dependence through higher visit and feeding rates, the specialised frugivores were more important dispersal agents than the opportunists. The specialists have been hypothesized to be the effective seed dispersers, disseminating seeds unharmed to microhabitats appropriate for seedling establishment (Mckey, 1975; Howe and Estabrook, 1977).

The fruit pigeons *T. phoenicoptera* and *T. pompadora* were found to digest many of the fig seeds. However, intact and undamaged seeds were also present in the pigeon faecal samples examinaed in this study. Lambert (1989) had described the fruit pigeons *Treron curvirostra* and *Chalcophaps indica* as seed predators which digested all the ingested seeds. Cowles and Goodwin (1959) had observed seed predatory behaviour in fruit pigeons. It was suggested that the utilisation of the seeds as well as the pulp of figs probably supplied the *Treron* species with a richer diet than taken by other fruit pigeons. The parrots were also described as seed predtors (Oslon and Blum, 1968; Janzen, 1981). The fruit pigeons crushed down the seeds while the parrots chewed the fruit pulp and crushed the seeds by their bills. The three parakeets P. cyanocephala, P. krameri and P. columboides were found to strip off the pulp with some seeds dropping a major portion of fig beneath the feeding tree Howe and Estabrook (1977) described birds that chewed fruits and swallowing the fruit pulp and dropping the seeds below the parent plant as "fruit theives". So the parakeets in this study might be considered as "fruit thieves".

Herrera (1984) classified avian frugivores into two categories, namely, "legitimate seed dispersers" and "fruit predators". The former ingested whole fruits and either regurgitated or defaecated the seeds intact. "Fruit predators" fed on either pulp or seeds alone and when eating pulp and seeds together, damage the latter either in the gut or prior to swallowing.

The opportunistic frugivores were also seen swallowing and voiding viable seeds. Hence they are also true or "legitimate dispersers" of Ficus seeds. The bird species such as T. pompadora, O. oriolus, and S. malabaricus, which were migrants in the site -I could be playing a very important role by dispersing the fig seeds to far off places.

Alternate fruit resources

Generally bird species with largely frugivorous diets required fruits of diverse taxa both in temperate and tropical habitats (Snow, 1977; Wheelwright, 1983; Herrera, 1984). Common members of the feeding assemblage differed widely in their use of the food plants.

In the Tenhipalam site the majour frugivores utilised a greater variety of fruit resources (Vijayakumar and Zacharias, 1992). The small Grean Barbet and Koel consumed fruits of the highest number of plant species ie; 39 and 35 repectively, out of 46 plant species studied during 1990-91. The common Green Pigeon ate mainly the berries of *Bridelia retusa* and *Macaranga Peltata*. Many other frugivores utilised a varied number of alternate fruit resources in this area. (Appendix - 1).

At Vythiri site also the diet of important fruit-eating species included a variety of allternate fruit resources (Appendix 2). Some of the most important plant species were *Trema orientalis*, *Litzea floribunda*, *Machelus macrantha*, *Olea indica* etc. The hornbill *T. griseus* and pigeon *D. badia* were preferring the fruits of Lauraceae than other fruits. Thus it is evident that the specialised frugivores are likely to be reliable dispersers for many fruiting plant species than are the opportunists. Similar findings have been made by Herrera (1984). The response of a fruit-eating bird to a particular fruit type depends on the configuration of the multispecies fruit supply at the community level, not just as species-specific structures. Herrera (1984) suggested that the bird species which often opted for nutrient rich fruit resources may also be effective dispersal agents of the low rewarding fruit species. The pigeon D. badia and the hornbill T. griseus which preferrably ate the nutrient rich lauraceous fruits, could also be dispersal agents of various less nutritious fruit-bearing Ficus trees.

According to Herrera (1984) the specific fruit resource composition in a habitat may largely determine the success of a given plant. The interpretation of the disperser ecology of a species requires a consideration of the set of species with which it is sharing the disperser assemblage. The results of the present study strongly supported this view. The degree of bird-to-plant and plant-to-bird selective pressures for any given species pair will probably depend on the degree of relative mutual abundance (Herrera, 1984).

SUMMARY AND CONCLUSION

T. N. Vijayakumar “Resource utilization by birds attending figs in South India”
Thesis. Department of Life Sciences , University of Calicut, 1994

CHAPTER 10

SUMMARY AND CONCLUSION

A three year study has been carried out between December 1989 and March 1993 on the mutualistic relationship operating between fruit-bearing plants and fruit-eating birds in two tropical habitats of Southern India, with special focus on _Ficus_ (Moraceae) fruits. Observations were conducted in a midland habitat at Tenhipalam and in an upland moist deciduous evergreen forest habitat at Vythiri. The fruiting plants and frugivorous birds attending them were surveilled extensively during this study.

The present investigation is thus an attempt at revealing the nature and kind of interaction between the fruiting plants and their avian frugivores. The figs represented a prominent fraction of the fleshy fruiting community in both the areas of present study. The population statuses of both _Ficus_ trees and avian frugivores were assessed during the fortnightly conducted censuses. Altogether fourteen species of figs were located at site I and nine species at site II. Observations were carried out on avian assemblage at ten and six species of figs each at these two sites respectively.

Data on flowering and fruiting patterns were gathered only on six species figs each at site I and site II. A detailed analysis of avian foraging activities were also done on them. The phenology of fruiting of *Ficus benghalensis*, *Ficus exasperata*, *F. racemosa*, *F. religiosa*, *F. amplissima*, *F. tsjahela* etc., at Tenhipalam and *F. exasperata*, *F. nervosa*, *F. beddomei*, *F. amplissima*, *F. microcarpa* and *F. tsjahela* at Vythiri were discussed in this study. A peak fruiting period has been observed in most fig species when most members of the population bore fruit, during the dry season (October through March). However, the fig populations contained members with abundant crop even in wet or monsoon season (June through September) which is usually a lean period of fruiting in fruit producing plants.

Totally twenty seven and twenty five species of birds each attended various fig crops at site I and site II respectively. The avian frugivore assemblage at figs comprised specialists with greater dependence on fruits as food source and opportunists which are primarily insectivores or animal feeding species. Data regarding frequency occurrence, frequency of visits, visitation length, feeding rates, fruit removal rates etc., were collected to assess the comparative efficiency of utilisation and dependence of different bird species on each fig crops. The specialists fruit eaters such as Green Pigeon, Barbet, Koel, Bulbul etc., had more intense interaction with fig crops than most opportunists like Common Myna, Greyheaded Myna, Hill Myna, Orioles, Crow, Tree Pie, Blue Bird etc.

However different assemblages of birds were seen at different fig species which were mainly influenced by the fig size, accessibility, spatial and temporal pattern of fruit production etc. The Green Pigeon and Coppersmith Barbet were observed to have greater preference to fig fruits than other fruit species in both the areas of present study. The time-budget which describes the time allocation pattern by foraging species for various behavioural activities would give better insight into the foraging behaviour and the energy requirement of a bird. The smaller bird species like barbets spent more time in feeding activities than larger species like Koel, Green Pigeon, Crow etc. Koel maintained feeding territories and spent enough time for defense of these territories from intruders either conspecific or others.

Variations in the foraging behaviour and fruit handling techniques employed by different bird species might have enabled them to lessen the intra- and interspecific competitions while sharing a common food resource. Similarly the differential use of different foraging sites also reduced the intensity of intraspecific and interspecific competitions. The avian foraging assemblages at figs contained both conspecific and mixed feeding flocks. The group foraging behaviour had a dual advantage. It enabled birds to locate the fruit resource easily and also to detect and escape predation by birds-of-prey.

The influence of various external forces such as climate, time-of-day and predation on resource utilisation were briefly discussed with reference to four important fig eating species like Koel, Barbets and Green Pigeon at the Tenhipalam site. The feeding activities were more intense in the morning and evening times and at relatively lower temperatures ($20^{o}C$ to $30^{o}C$). At mid-day time when the temperature was highest, the foraging activity declined considerably in the four species of birds studied. Rain also had an adverse effect on the avian activity. All the bird species suspended foraging at heavy showers.

The role of avian frugivore assemblages on seed dispersal is also discussed here quite briefly. The minute seeds of Ficus required themselves to be deposited in suitable sites like crevices and holes of neighbouring or distant trees and holes or crooks on walls of buildings and fences for successful germination. The faecal material of most birds contained intact and viable seeds. However the fig-eating specialist, Green pigeons were seen digesting many seeds in their alimentary passage. Hence, they are regarded as partial "seed predators". The parakeets were seen dropping most of the seeds with some pulp underneath the parent tree and are thus "fruit thieves". Though the specialists are more significant dispersal agents than opportunists as they have more intense interaction with figs, the latter are also important to figs as agents of dispersal. They also defecated intact and viable seeds.

Finally, a short discussion has also been made on the alternate fruit resources utilised by the avian frugivores at Tenhipalam and Vythiri sites. Though the fleshy figs attracted the greatest diversity of birds in the present investigation, many species such as Koel, Barbets, Bulbuls, Myna at Tenhipalam and Hornbill, Imperial Pigeon, Bulbuls etc. in the Vythiri site had haunted after other nutritious pulp-rich berries and other edible seeds.

Thus the present study on the utilisation of fruit resources by fruit-eating birds has clearly indicated the significant role of figs in the diet of birds. The soft, fleshy, small seeded characteristics of figs and their, relatively easy accessibility tended to be attractive to several frugivores. When many other nutritive and fleshy berries were taken by more specialists frugivores, the figs formed the food for many opportunists too. Another key role found to be played by figs in avian diet is their availability during the lean periods of fruiting in the monsoon season during this study. A chance for bias for such a conclusion in this instance is, however, not ruled out, since the figs had relatively greater representation in both the areas of present study. Yet the importance of *Ficus* fruits to fruit eating animals particularly birds cannot be underestimated as it was revealed in previous studies.

Recommendations

The following recommendations may be put forth on the basis of present observations and findings.

1. A delicate and balanced relationship exists between the frugivorous birds and fruiting plants in a habitat. The proper understanding of this interaction is essential for effective conservation and management of wildlife and maintenance of biodiversity.

2. To protect and conserve one species, a right knowledge of its food and feeding habits is essential. Different bird species have differential preferences to various fruit resources. For instance, the Malabar Grey Hornbill and Imperial Pigeon in the present study showed greater preference to berries of Lauraceae, particularly those of *Persea macrantha* in the Vythiri site.

3. The *Ficus* fruits formed the major food of many avian as well as mammalian frugivores in wild habitats and country sides. Also recognising their importance as a food resource during the lean season (monsoon), special attention may be given for their

propagation and conservation while framing wildlife management strategy.

4. The birds are effective, and sometimes most successful, dispersal agents for seeds of many fruiting plants in the forest ecosystem. Hence protection of these birds is also indispensable for conservation and management of plant community.

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APPENDIX 1

IMPORTANT ALTERNATE FRUIT RESOURCES AVAILABLE TO AVIAN FRUGIVORES AT TENHIPALAM SITE

Sl. No.	Plant species	Fruiting period
1.	*Adenathera pavonia* Linn.	March - June
2.	*Tabarina mundana*	July - November
3.	*Peltophorum* sp.	April - May
4.	*Canthium parviflorum* Lamk.	Aug - Sept.
5.	*Canthium rheedi* DC.	Sept - Oct.
6.	*Ziziphus oenoplia* (L.) Miller	July - Aug; March-April
7.	*Antedesma* sp.	July - Aug
8.	*Michelia champaka*	July - Sept.
9.	*Bridelia retusa* (L.) Sprengel	Nov - Dec.
10.	*Bridelia scandens* (Roxb.) Willd.	Jan - March
11.	*Memecylon edule* Roxb. Var. edule	Aug - Sept.
12.	*Lantana camara* L. var. aculeata (L.)	Throughout
13.	*Zanthoxylum rhetsa* (Roxb.) DC.	Oct - Feb
14.	*Naringi crenulata* (Roxb.) Nicolson	Aug - Sept
15.	*Polyalthia kronti*	Sept - Nov
16.	*Breynia vitis-idaea* (Fischer)	Sept - Oct
17.	*Cinnamomum veerum*	April - Aug
18.	*Macaranga peltata* (Roxb.) Muell. Arg.	Feb - May
19.	*Acacia auriculiformis* A. Cunn. ex Benth.	Dec - March
20.	*Ixora coccinea* Linn.	March - July

21.	_Chrysophyllum caineto_	Nov - Jan
22.	_Terminalia chebula_ (Retz.)	Dec - Feb
23.	_Terminalia bellirica_ (Gaertner) Roxb.	Nov - Jan
24.	_Terminalia paniculata_ (Roth)	Feb - April
25.	_Ardisia littoralis_	Jan - Feb
26.	_Sterculia guttata_ Roxb. ex DC.	Dec - Feb
27.	_Santalum album_ L.	Dec - Feb
28.	_Ilex_ sp.	Sept - Oct
29.	_Syzygium cumini_ (L.) Skeels	March - May
30.	_Syzygium caryophyllaeum_	April - July
31.	_Anamirta cocculus_ (Linn) Wight	Dec - Jan
32.	_Rauvolfia tetraphylla_ (Linn.)	July - Jan
33.	_Bungara malabarica_ Lam.	May - Aug
34.	_Mimusops elengi_ L.	Sept - Dec
35.	_Histonia mystax_	Aug - Sept
36.	_Psidium guava_ Linn.	July - Dec
37.	_Litzea coriacea_ (Heyne ex Meissu.)	July - Sept
38.	_Litzea decadens_	Aug - Sept
39.	_Olea dioica_ Roxb.	Feb - March
40.	_Mangifera indica_ L.	April - June
41.	_Anacardium occidentale_ Linn.	Feb - May
42.	_Flacourtia indica_	July - Aug
43.	_Leea indica_ (Burm. f.) Merr.	Aug - Sept
44.	_Erythrina indica_ Lamk.	May - June
45.	_Phyllanthus emblica_ Linn.	Nov - Feb
46.	_Trema orientalis_ (Linn.) Blume	April - May

47. *Carellia brachiata* March - April

48. *Roystonea regia* May - June

49. *Glaricidia* sp. March - April

50. *Cipadessa* sp. March - April

51. *Syzigium jambolanum* April - May

52. *Artabotryllus* sp. March - May

53. *Cinnamomum didymum* July - Aug

54. *Polyalthia longifolia* July - Sept.

APPENDIX 2

IMPORTANT ALTERNATE FRUIT RESOURCES UTILISED BY AVIAN FRUGIVORES AT VYTHIRI SITE

Sl. No.	Plant species	Fruiting period
1.	*Litsea ligusterina*	Feb - March
2.	*Litsea floribunda* (Bl.) Gamb.	April - May
3.	*Litsea scorbiculata*	April - May
4.	*Litsea zeylanica* Hook. f.	May - June
5.	*Litsea laevigata* (Nees) Gamb.	Feb - April
6.	*Litsea wightiana* Wall. ex Hook. f.	Sept - January
7.	*Neolitsea scrobiculata* (Meiss.) Gamb.	March - April
8.	*Actinodaphne bourdilloni* Gamb.	Nov. - January
9.	*Persea macrantha*	Jan - April
10.	*Elaeocarpus glandulosus* Wall. ex Merr.	April - May
11.	*Elaeocarpus tuberculatus* Roxb.	May - June
12.	*Elaeocarpus oblongus* Wight and Arn.	Sept - October
13.	*Olea dioica*	Feb - March
14.	*Artocarpus integrifolia* Roxb.	April - June
15.	*Artocarpus hirsuta*	May - June
16.	*Croton zeylanica* Muell.	March - April
17.	*Bischofia javanica* Bl.	Jan - April
18.	*Maesa perrottetiana* A. Dc.	March - May
19.	*Lantana camara* L. var. *aculeata* (L.)	Throughout
20.	*Lantana aculeata* L.	Throughout

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21.	_Eurya nitida_	May - June
22.	_Bridelia scadens_ (Roxb.) Willd.	Sept - Oct.
23.	_Coffea arabica_	Feb.-March-April
24.	_Piper nigrum_	Jan - March
25.	_Mangifera indica_ L.	April - May - June
26.	_Elettaria cardamomum_ (L.) Maton	Sept - Oct.
27.	_Antidesma bunius_ (L.) Spreng	July - Sept.
28.	_Antidesma paniculatum_ (Roxb.)	Jan - Feb
29.	_Erythrina lithosperma_	March - Aug.
30.	_Erythrina indica_	Feb - May
31.	_Eugenia microphylla_ Budd.	March - April
32.	_Eugenia garceneri_ Thw.	Aug - Sept.
33.	_Sterculia allata_	Nov - Jan.
34.	_Sterculia visculosa_	June - July
35.	_Sterculia guttata_ Roxb.	April - May
36.	_Trema orientalis_ (L.) Bl.	April - May
37.	_Nothopegia beddomei_ Gamb.	Sept. - Jan.
38.	_Cinnamomum zeylanicum_	Sept. - Dec.
39.	_Terminalia chebula_	April - May
40.	_Macaranga peltata_ (Roxb.) Muell. Arg.	April - May
41.	_Mallotus tetracocus_ (Roxb.) Kurz.	Jan - March
42.	_Mallotus albus_ Muell	Jan - Feb.
43.	_Cullenia excelsa_ Wight	June - Sept.
44.	_Garcinia cambogia_ (Gaertn.) Desr.	Aug - Oct.

45.	*Muraya paniculata* (Linn.)	Oct - Nov.
46.	*Melia azadirachta* Brandis	July - Aug.
47.	*Dysoxylum glandulosum*	June - Sept.
48.	*Bassia elliptica* Daz.	May - June
49.	*Mallotus philippinensis* (Lamk) Mule. Arg.	Jan - Feb.
50.	*Phyllanthus emblica* Linn.	Nov - Jan.
51.	*Grewia tilliaefolia*	April - May
52.	*Mesopsis cumini*	April - May

APPENDIX 3

LIST OF BIRDS RECORDED AT TENHIPALAM SITE

Ardeidae

1. Indian Pond Heron - *Ardeola grayii*
2. Cattle Egret - *Bubulcus ibis*
3. Little Egret - *Egretta garzetta*

Accipitridae

4. Blackwinged Kite - *Elanus caeruleus*
5. Crested Honey Buzzard - *Pernis ptilorhynchus*
6. Common Pariah Kite - *Milvus migrans*
7. Brahminy Kite - *Haliastur indus*
8. Shikra - *Accipiter badius*
9. Japanese Desert Buzzard - *Buteo buteo*

Rallidae

10. Whitebreasted Waterhen - *Amaurornis phoenicurus*
11. Indian Moorhen - *Gallinula chloropus*

Charadriidae

12. Redwattled Lapwing - *Vanellus indicus*
13. Yellow-wattled Lapwing - *Vanellus malabaricus*
14. Little Ring Plover - *Charadrius dubius*

Burhinidae

15. Stone Curlew - *Burhinus oedicnemus*

Columbidae

16. Common Green Pigeon - *Treron phoenicoptera*
17. Greyfronted Green Pigeon - *Treron pompadora*
18. Orangebreasted Green Pigeon - *Treron bicincta*
19. Blue Rock Pigeon - *Columba livia*
20. Spotted Dove - *Streptopelia chinensis*
21. Emerald Dove - *Chalcophaps indica*

Psittacidae

22. Roseringed Parakeet - *Psittacula krameri*
23. Blossomheaded Parakeet - *Psittacula cyanocephala*
24. Malabar Lorikeet - *Loriculus vernalis*

Cuculidae

25. Pied Crested Cuckoo - *Clamator jacobinus*
26. Common Hawk - Cuckoo - *Cuculus varius*
27. Indian Cuckoo - *Cuculus micropterus*
28. Baybanded Cuckoo - *Cacomantis sonneratii*
29. Indian Plaintive Cuckoo - *Cacomantis merulinus*
30. Indian Koel - *Eudynamys scolopacea*
31. Southern Crow-Pheasant - *Centropus sinensis*

Strigidae

32. Barn Owl - *Tyto alba*

33. Indian Great Horned Owl - *Bubo bubo*

34. Malabar jungle owlet - *Glaucidium radiatum*

35. Southern spotted owlet - *Athene brama*

36. Mottled Wood Owl - *Strix ocellata*

Caprimulgidae

37. Common Indian Nightjar - *Caprimulgus asiaticus*

Apodidae

38. House Swift - *Apus affinis*

39. Palm swift - *Cypsiurus parvus*

Alcedinidae

40. Pied Kingfisher - *Ceryle rudis*

41. Common Ceylon Kingfisher - *Alcedo atthis*

42. Whitebreasted Kingfisher - *Halcyon smyrnensis*

Meropidae

43. Bluetailed Bee-eater - *Merops philippinus*

44. Small Green Bee-eater - *Merops orientalis*

Coraciidae

45. Indian Roller - Coracias benghalensis

Upupidae

46. Ceylon Hoopoe - Upupa epops

Capitonidae

47. Small Green Barbet - Megalaima virdis (Boddaert)

48. Crimsonbreasted Barbet - Megalaima haemacephala

Picidae

49. Southern Rufous Woodpecker - Micropternus brachyurus

50. South Indian Small Yellownaped Woodpecker - Picus myrmecophoneus

51. Malabar Goldenbacked Woodpecker - Dinopium benghalense

52. Malabar Pigmy Woodpecker - Dendrocopos nanus

53. Heartspotted Woodpecker - Hemicircus canente

Pittidae

54. Indian Pitta - Pitta brachyura

Alaudidae

55. Bush Lark - Mirafra assamica

56. Malabar Crested Lark - Galerida malabarica (Scopoli)

Hirudinidae

57. Eastern Swallow - *Hirundo rustica*

58. Redrumped Swallow - *Hirundo daurica*

Laniidae

59. Baybacked Shrike - *Lanius vittatus*

60. Brown Shrike - *Lanius cristatus*

Oriolidae

61. Indian Oriole - *Oriolus oriolus*

62. Black-headed Oriole - *Oriolus xanthornus*

Dicruridae

63. Black Drongo - *Dicrurus adsimilis*

64. Indian Grey Drongo - *Dicrurus leucophaeus*

65. Bronze Drongo - *Dicrurus caerulescens*

66. Racket-tailed Drongo - *Dicrurus paradiseus*

Artamidae

67. Ashy Swallow-Shrike - *Artamus fuscus* Vieillot

Sturnidae

68. Greyheaded Myna - *Sturnus malabaricus*

69. Brahminy Myna - *Sturnus pagodarum*

70. Rosy Pastor - *Sturnus roseus* (Linnaeus)

71. Common Myna - *Acridotheres tristis*

72. Southern Jungle Myna - *Acridotheres fuscus*

Corvidae

73. Tree Pie - *Dendrocitta vagabunda*

74. House crow - *Corvus splendens*

75. Jungle Crow - *Corvus macrorhynchos*

Campephagidae

76. Common Wood Shrike - *Tephrodornis pondicerianus*

77. Large Indian Cuckoo-Shrike - *Coracina novaehollandiae*

78. Blackheaded Cuckoo - Shrike - *Coracina melanoptera*

79. Malabar Small Minivet - *Pericrocotus cinnamomeus*

Irenidae

80. Iora - *Aegithina tiphia*

81. Goldenfronted Chloropsis - *Chloropsis aurifrons*

Pycnonotidae

82. Redwhiskered Bulbul - *Pycnonotus jocosus*

83. Redvented Bulbul - *Pycnonotus cafer*

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Muscicapidae

84. Jungle Babbler - *Turdoides striatus*

85. Whiteheaded babbler - *Turdoides affinis*

86. Brown Flycatcher - *Muscicapa latirostris*

87. Whitebrowed Fantail Flycatcher - *Rhipidura aureola*

88. Paradise Flycatcher - *Tersiphone paradisi*

89. Ashy Wren - Warbler - *Prinia socialis*

90. Tailor Bird - *Orthotomus sutorius*

91. Blyth's Reed Warbler - *Acrocephalus dumetorum*

92. Bright Green Leaf Warbler - *Phylloscopus nitidus*

93. Magpie - Robin - *Copsychus saularis*

94. Whitethroated Ground Thrush - *Zoothera citrina*

Motacillidae

95. Malay Pipit - *Anthus novaeseelandiae*

96. Large Pied Wagtail - *Motacilla maderaspatensis*

Dicaeidae

97. Tickell's Flowerpecker - *Dicaeum erythrorhyncos*

Nectariniidae

98. Purplerumped Sunbird - *Nectarinia zeylonica*

99. Loten's Sunbird - *Nectarinia lotenia*

100. Purple Sunbird - *Nectarinia asiatica*

Ploceidae

101. House Sparrow - Passer domesticus

102. Baya Weaver Bird - Ploceus philippinus

103. White-backed Munia - Lochura striata

104. Spotted Munia - Lochura punctulata

105. Blackheaded Munia - Lochura malacca

APPENDIX 4

LIST OF BIRDS OBSERVED AT VYTHIRI

Family *Accipitridae*

1. Legges Baza - *Aviceda jerdoni*
2. Crested Honey Buzzard - *Pernis ptilorhyncus*
3. Ceylon Shikra - *Accipiter badius*
4. Crested Goshawk - *Accipiter trivirgatus*
5. Asiatic Sparrow Hawk - *Accipiter nisus*
6. Japanese Desert Buzzard - *Buteo buteo*
7. Indian Crested Hawk-Eagle - *Spizaetus cirrhatus*
8. Bonelli's Hawk - Eagle - *Hieraaetus fasciatus*
9. Black Eagle - *Ictinaetus malayensis*
10. Smaller White Scavenger Vulture - *Neophron percnopterus*
11. Pale Harrier - *Circus macrourus*
12. Crested Serpent Eagle - *Spilornis cheela*

Falconidae

13. Shahin Falcon - *Falco peregrinus*
14. Indian Kestrel - *Falco tinnunculus*

Phasianidae

15. Painted Bush Quail - *Perdicula erythrorhynca*
16. Travancore Red Spurfowl - *Galloperdix spadicea*

17. Grey Jungle Fowl - Gallus sonneratii Temminck

Columbidae

18. Greyfronted Green Pigeon - Treron pompadora
19. Jerdon's Imperial Pigeon - Ducula badia
20. Nilgiri Wood Pigeon - Columba elphinstonii
21. Indian Spotted Dove - Streptopelia chinensis
22. Emerald Dove - Chalcophaps indica

Psittacidae

23. Blossomheaded Parakeet - Psittacula cyanocephala
24. Bluewinged Parakeet - Psittacula columboides
25. Malabar Lorikeet - Loriculus vernalis

Cuculidae

26. Common Hawk-Cuckoo - Cuculus varius
27. Indian Cuckoo - Cuculus micropterus
28. Baybanded Cuckoo - Cacomantis sonneratii
29. Indian Plaintive Cuckoo - Cacomantis merulinus
30. Crow-Pheasant - Centropus sinensis

Strigidae

31. Collared Scops Owl - Otus bakkamoena
32. Indian Scops Owl - Otus scops
33. Forest Eagle Owl - Bubo nipalensis

34. Malabar Jungle Owlet - *Glaucidium radiatum*

35. South Indian Hawk-Owl - *Ninox scutulata*

36. Spotted Owlet - *Athene brama*

37. Mottled Wood Owl - *Strix ocellata*

38. Brown Wood Owl - *Strix leptogrammica*

Caprimulgidae

39. Jerdon's Longtailed Nightjar - *Caprimulgus macrurus*

40. Indian Jungle Nightjar - *Caprimulgus indicus*

Apodidae

41. Whiterumped Spinetail Swift - *Chactura sylvatica* (Tickell)

42. Indian Alpine Swift - *Micropus melba*

Alcedinidae

43. White-breasted Kingfisher - *Halcyon smyrnensis*

44. Common Ceylon Kingfisher - *Alcedo atthis*

Meropidae

45. Chestnutheaded Bee-eater - *Merops leschenaulti*

46. Small Green Bee-eater - *Merops orientalis*

Bucerotidae

47. Malabar Grey Hornbill - *Tockus griseus*

Capitonidae

48. Small Green Barbet - *Megalaima virdis*

49. Crimsonthroated Barbet - *Megalaima rubricapilla*

Picidae

50. Nilgiri speckled Piculet - *Picumnus innominatus*

51. Southern Rufous Woodpecker - *Micropterus brachyurus*

52. Scalybellied Green Woodpecker - *Ficus myrmecophoneus*

53. Malabar Goldenbacked Woodpecker - *Dinopium benghalense*

54. Malabar Goldenbacked Threetoed Woodpecker - *Dinopium javanese*

55. Malabar Great Black Woodpecker - *Dryocopus javensis*

56. Pigmy Woodpecker - *Dendrocopos nanus*

57. Heartspotted Woodpecker - *Hemicircus canente*

Pittidae

58. Indian Pitta - *Pitta brachyura*

Alaudidae

59. Malabar Crested Lark - *Galerida malabarica* (Scopoli)

Hirundinidae

60. Dusky Crag Martin - *Hirundo concolor*

61. Eastern Swallow - *Hirundo rustica*

62. Nilgiri House Swallow - *Hirundo tahitica*

63. Redrumped Swallow - *Hirundo daurica*

Laniidae

64. Brown Shrike - Lanicus cristatus

65. Southern Greybacked Shrike - Lanius schach

Oriolidae

66. Golden Oriole - Oriolus oriolus

Dicruridae

67. Black Drongo - Dicrurus adsimilis

68. Bronzed Drongo - Dicrurus aeneus

69. Indian Grey Drongo - Dicrurus leucophaeus

70. Haircrested Drongo - Dicrurus hottentotus

71. Racket-tailed Drongo - Dicrurus paradiseus

Sturnidae

72. Blyth's Myna - Sturnus malabaricus (Gmelinin)

73. Southern Jungle Myna - Acridotheres fuscus

74. Southern Gracke or Hill Myna - Gracula religiosa

Corvidae

75. Southern Tree Pie - Dendrocitta leucogastra Gould

76. Jungle Crow - Corvus macrorhyncos

Campephagidae

77. Blackbacked Pied Flycatcher-Shrike - *Hemipus picatus*

78. Malabar Wood Shrike - *Tephrodornis virgatus*

79. Common Wood Shrike - *Tephrodornis pondicerianus*

80. Large Indian Cuckoo-Shrike - *Coracina novaehollandiae*

81. Blackheaded Cuckoo-Shrike - *Coracina melanoptera*

82. Scarlet Minivet - *Pericrocotus flammeus*

83. Small Minivet - *Pericrocotus cinnamomeus*

Irenidae

85. Iora - *Aegithina tiphia*

86. Goldfronted Chloropsis - *Chloropsis aurifrons*

87. Jerdon's Chloropsis - *Chloropsis cochinchinensis*

88. Fairy Bluebird - *Irena puella*

Pycnonotidae

89. Greyheaded Bulbul - *Pycnonotus priocephalus*

90. Rubythroated Bulbul - *Pycnonotus melanicterus*

91. Redwhiskered Bulbul - *Pycnonotus jocosus*

92. Redvented Bulbul - *Pycnonotus cafer*

93. Yellowbrowed Bulbul - *Hypsipetes indicus*

94. Black Bulbul - *Hypsipetes madagascariensis*

Muscicapidae

95. Travancore Spotted Babbler - Pellorneum ruficeps

96. Travancore Scimitar Babbler - Pomatorhinus schisticeps

97. Blackheaded Babbler - Rhopocichla atriceps

98. Rufous Babbler - Turdoides subrufous

99. Wynaad Laughing Thrush - Garrulax delesserti

100. Quaker Babbler - Alcippe poioicephala

101. Layard's Flycatcher - Muscicapa muttui

102. Rufoustailed Flycatcher - Muscicapa ruficauda

103. Eastern Redbreasted Flycatcher - Muscicapa parva

104. White-bellied Blue Flycatcher - Muscicapa pallipes Jerdon

105. Bluethroated Flycatcher - Muscicapa rubeculoides

106. Tickell's Blue Flycatcher - Muscicapa tickelliae

107. Verditer Flycatcher - Muscicapa thalassina

108. Nilgiri Verditer Flycatcher - Muscicapa albicaudata

109. Greyheaded Flycatcher - Culicicapa ceylonensis

110. Paradise Flycatcher - Terpsiphone paradisi

111. Blacknaped Blue Flycatcher - Monarcha azurea

112. Ashy Wren-Warbler - Prinia socialis

113. Coorg Wren-Warbler - Prinia hodgsonii

114. Travancore Streaked Fantail Warbler - Cisticola juncidis

115. Tailor Bird - Orthotomus sutorius

116. Broadtailed Grass Warbler - Schoenicola platyura (Jerdon)

117. Thickbilled Warbler - Phragamaticola aedon

118. Bright Green Leaf Warbler - <u>Phylloscopus nitidus</u>

119. Greenish Leaf Warbler - <u>Phyllscopus trochiloides</u>

120. Blyth's Reed Warber - <u>Acrocephalus dumetorum</u> Blyth

121. Magpie-Robin - <u>Copsychus saularis</u>

122. Shama - <u>Copsychus malabaricus</u>

123. Indian Blue Chat - <u>Erithacus brunneus</u>

124. Pied Bush Chat - <u>Saxicola caprata</u>

125. Blueheaded Rock Thrush - <u>Monticola cinchlorhyncus</u> (Vigors)

126. Blue Rock Thrush - <u>Monticola solitarius</u>

127. Malabar Whistling Thrush - <u>Myiophaneus horsfieldii</u>

128. White-throated Ground Thrush - <u>Zoothera citrina</u>

129. Blackbird - <u>Turdus merula</u>

<u>Paridae</u>

130. Yellowcheeked Tit - <u>Parus xanthogenys</u>

<u>Sittidae</u>

131. Velvetfronted Nuthatch - <u>Sitta frontalis</u>

<u>Motacillidae</u>

132. Nilgiri Pipit - <u>Anthus nilghiriensis</u> Sharpe

133. Grey Wagtail - <u>Motacilla caspica</u>

134. Forest Wagtail - <u>Motacilla indica</u> Gmelin

135. Large Pied Wagtail - <u>Motacilla maderaspatensis</u> Gmelin

Dicaeidae

136. Thickbilled Flowerpecker - Dicaeum agile

137. Tickell's Flowerpecker - Dicaeum erythrorhynchos

138. Nilgiri Flowerpecker - Dicaeum concolor

Nectarinidae

139. Purplerumped Sunbird - Nectarinia zeylonica

140. Small Sunbird - Nectarinia minima (Sykes)

141. Loten's Sunbird - Nectarinia lotenia

Zosteropidae

142. Nilgiri White-eye - Zosterops palpebrosa

Ploceidae

143. White-backed Munia - Lochura striata

144. Rufousbellied Munia - Lochura kelaarti

145. Spotted Munia - Lochura punctulata

Fringillidae

146. Indian Rosefinch - Carpodacus erythrinus