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INTRODUCTION

Birds are often serious pests of rice. The small size of this cereal at all stages of its ripening makes it attractive for the small, seed-eating birds. Considerable damage also is inflicted during early stages of growth when germinating seedlings are depredated by grainivores, and several species of aquatic birds trample the fields in search of food. The migratory blackbirds (*Agelaius* species and others) eat various grains across the U.S.A. and Mexico, while huge numbers of red-billed weaver bird (*Quelea quelea*) account for grain losses up to 20% in several rice-growing African countries (Efferson, 1952).

Although rice is the staple food for the majority of India, information available on bird damage to paddy is inadequate. Spotted munia (Hamid Ali et al., 1976; Saha and Mukherjee, 1978; Verghese and Chakravarthy, 1981) and baya (Mathew, 1976; Hamid Ali et al., 1976) are the recognized pests of rice. A host of insectivorous birds prey upon the abundant insect pests of rice. Studies on ecology of rice field birds and their foraging patterns will aid in formulating the best possible measures to prevent damage. Hence, in this preliminary study, data on the density and diversity of birds visiting a paddy field, their spatial and temporal distribution, feeding behavior, and foraging strategy were collected.

METHODS AND MATERIALS.

The Study Area

The data were collected in a 4-ha paddy field belonging to University of Agricultural Sciences at Hebbal, Bangalore. The study plot was continuous with paddy fields on two sides; a vegetable garden of fairly dense vegetation was on the third side, while a bund on the fourth side separated the fields from an irrigation tank. Paddy is cultivated twice a year. The *khariff* crop is grown from June to September and summer crop from February to May. Depending on early or delayed rains, the cropping schedule varies by a month or two. *Rabi* crop is grown from October to January in places where adequate water is available. The growth of paddy can be divided into five stages: transplanted, tillering, heading, ripening and post-harvest.

The site, at an altitude of 925 m above sea level, is characterized by hot summers extending from March to May, heavy rains from June to August, autumn from September to November, and mild winters from December to February. The mean temperature is 25 $\pm$ 3° C.

Methods

The density and diversity of birds visiting and foraging in the study area were recorded during *khariff* from September 1980 to January 1981, and summer crop from February to June 1981. Density was recorded according to the standarized time-census

method described by Holmes and Sturges (1974). The method consisted of two observers walking slowly and synchronously on fixed, parallel lines in the study area with a minimum distance of 50 m between them, recording the species, position on the plot, and activity of every bird seen or heard within 25 m on either side of their path. Such recordings were made at hourly intervals starting at 0800 and culminating at 1700. These censuses were conducted on two consecutive days every fortnight and then averaged for the month. Density was represented as birds/ha/hr. Diversity was calculated according to Chanter and Owen (1976), which is given by Simpson's index (Simpson, 1949):

$$\lambda = \frac{\sum_{j=1}^{k} n_j \, (n_j - 1)}{N \, (N-1)}$$

where N represents the total number of birds belonging to k different species in an area, the number of each species seen being $n_1, n_2 \ldots n_k$ ($n = N$). A more appropriate index for diversity, according to Chanter and Owen (1976), is:

$$\beta = 1 - \lambda$$

According to the same authors, a combined index, known as visitor's satisfaction index, was calculated as:

$$\Theta = \log (\beta N)$$

The birds were categorized as to grainivorous, carnivorous or insectivorous food preferences. The parameters of feeding behavior included aerial feeding, fly catching, and gleaning by insectivores; gleaning and probing by carnivores; plucking from the ear head, and gleaning by grainivores.

For comparing the economics of avian foraging, the biomass expressed as g/ha was calculated for grainivores and insectivores during heading and ripening stages and their ratios calculated (Table 2). Only major grainivores such as baya, munia, and parakeet were taken into account, while drongo, myna, and roller were considered under insectivores. Paddy loss due to feeding of grainivores was extrapolated from their feeding rates reported earlier and numbers seen in the present study (Table 3). Table 4 illustrates the extent of loss of paddy due to pests and diseases. Losses due to insects, cold, and diseases have been calculated from percent loss figures provided by the Farm office, Main Research Station, Hebbal. Since rodent damage was not assessed for this period, estimates have been included from our earlier work in the same fields (Sridhara & Krishnamoorthy, 1978/79).

RESULTS AND DISCUSSION

Table 1 lists the various species of birds seen, their seasonal status, and foraging pattern in the study area. The standing water in the rice fields as well as the irrigation canals harbour water beetles, water bugs, odonates, and a variety of other insects in addition to earthworms, crabs, fishes, frogs, and tadpoles, which provide ample food supply for carnivorous birds. In addition, small vertebrates like frogs, lizards, mice, and young birds are predated upon by kites. The abundant and diverse insect fauna of paddy fields comprising mealy bug, thrips, leaf hopper, brown plant hopper, gall fly, stem borer, leaf roller, whorl maggot, case-worm, cut-worm, grasshopper, swarming caterpillar, leptispa, hispa, and gundibug accounts for the array of insectivorous birds seen in the field. The grainivorous birds were represented by baya weaver, blue-rock pigeon, spotted dove, parakeet, and spotted munia.

Density and Diversity

Comparison of density and diversity of bird fauna at different stages of paddy growth showed that the two parameters were minimum during transplanted and tillering stages, maximum during heading, and declined after harvest in *khariff* (Fig. 1a).

In the summer season when the grain was ripening, the density and diversity of birds were maximum (Fig. 1b). Minimum density and diversity at heading stage, when the crop is capable of supporting large numbers of insectivores and grainivores, perhaps is related to these depredators breeding during April-May (the time of heading). Activities related to breeding impose increased time demands, and grain eaters shift from grains to insects to feed nestlings (Mathew, 1976; Simwat, 1977). Both density and diversity of birds were less at transplanted and tillering stages of *khariff* but more in the subsequent stages compared to summer crop.

During *khariff* bird density was minimum at 12 noon (or 1200 hours) at all stages of paddy (Fig. 2a). However, during summer minimum bird population was seen between 1100 to 1300 hours (with the exception of ripening stage) (Fig. 2b). In contrast, highest avian populations occurred at 1700 hours at all stages during both the seasons (Fig. 2a and b). The summer afternoons are hot, humid, and lengthy; population is minimum from 1100 to 1300 hours.

In *khariff* conditions are not so severe, and minimum density is seen for a shorter duration at 1200 hours. The evening peaks result from the return of birds to roosting sites as well as the late afternoon drops in temperature. The diversity of bird species was high in the morning, gradually declined to a minimum at or near 1200 hours at all stages of paddy both during *khariff* and summer, and was maximum in the evening at 1700 hours at almost all stages (Fig. 3a and b).

Foraging Behavior

Carnivores: Egrets and herons formed flocks of 20 to 30 in the morning and evening but remained solitary for most of the day (Fig. 6). They roosted together on a nearby banyan tree. Plovers were seen in similar flocks of 20 to 30, while kingfisher, kite, red-wattled lapwing, black-winged stilt, and dabchick were solitary feeders.

Insectivores: Myna, sparrow, swallow, swift, and warblers were flock feeders. Of these, swallow and swift were aerial fly catchers; the rest ground feeders. The other insectivores, like drongo, blue jay (roller), wagtail, cuckoo, cuckoo-shrike, etc., were solitary. Of these, the wagtail was a ground feeder. The others perched on trees, telegraph wires, and fences, sweeping down to rice plants/ground to prey upon the insects.

Granivores: Baya weavers were always in flocks of 15-20 and perched on paddy plants while feeding. Similar feeding behavior was also exhibited by munia (Fig. 5). Both the species depredated on the grain throughout the day but to a lesser extent over the mid-day period. Pigeons and parakeets in small flocks of 6-10 and solitary doves visited the fields after 1500 hours and were active in the twilight. Parakeets fed directly from the plant, while the other two picked grains fallen on the ground.

Nests: Only nests of baya (Fig. 4a and b) and tailor birds were seen on coconut and mulberry trees, respectively. Parakeets were hole nesting in an adjacent banyan tree, while pigeons and doves nested on nearby buildings. Mynas nested in large banyan trees one km away from the fields.

Economic Aspects: The economics of bird foraging in paddy fields has two aspects: beneficial by way of predation on insects injurious to the crop, but harmful due to grain loss by the feeding activities of grainivores.

Black drongo, myna, swift, roller, swallow, and crow have been reported to be helpful in controlling insects injurious to paddy (Mathew et al., 1980; Tirumurthi et al., 1981; Nathan and Rajendran, 1982). Of these, drongo, roller, and myna feed on insect pests of paddy to a far greater extent than others (Mathew et al., 1980; Tirumurthi et al., 1981; Nathan and Rajendran, 1982). Hence they all need encouragement to visit, perch, and roost around paddy fields. This can be done by encouraging the growth of moderate sized trees such as *Pongamia glabra* inside the paddy field, since both drongo and roller are observed to perch on look-out points, keeping a vigilant watch for insects. The tree is ideal, because not only can it serve as a hunting perch and nesting site for roller and

drongo and roosting site for myna, but its leaves serve the additional purpose of providing green manure, a traditional practice in this part of India.

The details of relative biomass of important grainivores and insectivores are presented in Table 2. During both *khariff* and summer biomass of insectivores is higher (highest in summer), implying greater foraging and hence more destruction to insects of paddy field.

Grain loss due to birds has been shown to be more during *khariff* (3.9 to 22%) compared to 1.7 to 3.1% of *rabi* in Andhra Pradesh (Hamid Ali et al., 1976). Greater loss during *khariff* compared to summer also is seen in the present study (Tables 3 and 4). Although Saha and Mukherjee (1978) estimated a daily loss of 5 kg/day/species due to the feeding activities of black-headed and spotted munia in Assam, the latter accounted for a loss of 4.75 kg/ha and 1.13 kg/ha during *khariff* and summer crops, respectively, in the current study. The *khariff* grain loss due to baya is 13.85 kg/ha, similar to 12.15 kg/ha reported for the same season by Hamid Ali et al., (1980) for Andhra Pradesh. However, their estimated loss during *rabi* of 9.66 kg/ha, though less than in *khariff,* is higher than our 3.47 kg/ha loss estimated for summer crop (Table 3).

In Table 4 a comprehensive picture of losses due to pests, diseases and cold is presented. For *khariff* the actual loss is 1800 kg, whereas the estimated loss due to the cumulative destructive activities is only 1611 kg. Similarly for summer only 573 kg can be accounted for, while factual loss is 700 kg. The probable reason could be nonavailability of exact figures for losses due to insects, diseases, cold, and rodents during the present investigation.

CONCLUSION

Damage by munia is negligible, whereas baya affect the paddy crop to a small extent in and around Bangalore. The latter observation is in agreement with Mathew's (1976) view that baya do not cause serious damage to paddy. Paddy fields around Bangalore do not warrant serious bird control measures apart from traditional methods, like scarecrows, drumming, and shouting carried out by paid labourers, since the level of damage by birds is low compared to that of other damaging factors. Density of grainivores is less, and the sophisticated methods of bird control such as shooting, gametocide, dispersal by recorded calls, repellents, and acetylene exploders are beyond the skill and budget of an average Indian farmer.

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TABLE 1: Species of birds* seen in paddy fields during 1981-82.

Species	Seasonal status	Foraging pattern
1. Small Blue Kingfisher, *Alcedo atthis*	R	C-P
2. Pied Kingfisher, *Ceryle rudis*	R	C-P
3. Indian Myna, *Acridotheres tristis*	R	O-GI
4. Jungle Myna, *Acridotheres fuscus*	R	I-AF
5. Pond Heron, *Ardeola grayii*	R	C-P
6. Little Ringed Plover, *Charadrius dubius*	R	C-P
7. Little Egret, *Egretta garzetta*	R	C-P
8. House Crow, *Corvus splendens*	R	C-P
9. Jungle Crow, *Corvus macrorhynchos*	R	O
10. Red-rumped Swallow, *Hirundo daurica*	R	I-AF
11. Baya Weaver Bird, *Ploceus philippinus*	R	G-PL
12. Brahminy Kite, *Haliastur indus*	R	G-GI
13. Common Pariah Kite, *Milvus migrans*	R	G-GI
14. Black Drongo, *Dicrurus adsimilis*	R	I-FC
15. Pied Crested Cuckoo, *Clamator jacobinus*	R	I/O-AF
16. Rose-ringed Parakeet, *Psittacula krameri*	R	G-OL
17. Roller, *Coracias benghalensis*	R	C-GL
18. House Swift, *Apus affinis*	R	I-AF
19. Large Pied Wagtail, *Motacilla moderaspatensis*	R	I-GI
20. Blue Rock Pigeon, *Columba livia*	R	G-GI
21. Spotted Dove, *Streptopelia chinensis*	R	G-GI
22. Streaked Fantail Warbler, *Cisticola juncidis*	R	I-GI
23. House Sparrow, *Passer domesticus*	R	O-GI
24. Spotted Munia, *Lonchura punctulata*	R	G-PI
25. Tailor Bird, *Orthotomus sutorius*	R	I-GI P
26. Koel, *Eudynamys scolopacea*	R	O
27. Red-wattled Lapwing, *Vanellus indicus*	R	C-GI
28. Black-headed Cuckoo-Shrike, *Coracina melanoptera*	R	O
29. Black-winged Stilt, *Himantopus himantopus*	R	C-GI
30. Dabchick, *Podiceps ruficollis*	R	C
31. Coppersmith, *Megalaima haemacephala*	R	O
32. Purple Sunbird, *Nectarinia asiatica*	R	O

R = resident; C = carnivorous; I = insectivorous; G = grainivorous; O = omnivorous; P = prober; GI = gleaner; AF = aerial feeder; FC = flycatcher; PL = plucker

* Ali (1972)

TABLE 2. Comparison of biomass (g/ha) of insectivorous and grainivorous birds in the paddy fields during *khariff* 1980 and summer 1981.

	Grainivores*			Insectivores*	
	Species	*Khariff*	Summer	Species	*Khariff*	Summer
	Baya weaver	1937	605	Drongo	-	171
	Parakeet	159	1179	Myna	7110	6424
	Munia	27	7	Roller	-	855
Total biomass/ha		2123	1791		7110	7449
			Ratio of grainivores: insectivores			
			khariff		*summer*	
			1: 3.349		1: 3.159	
			*only for ripening and heading stage.			

TABLE 3. Loss caused by Baya and Munia during *khariff* and summer of 1980-81.

	Kkhariff		Summer	
	heading	ripening	heading	ripening
Baya				
Number of Baya seen/day/4 ha	327	269	19.0	167
Number of Baya seen/month/4 ha	9810	8070	470	4010
Loss due to feeding by Baya*/4 ha	30.4 kg.	25.0 kg	1.457 kg.	12.4 kg.
Total loss/ha/season	13.85 kg		3.472 kg	
Munia				
Number of Munia seen/day/4 ha	—	8	—	2
Number of Munia seen/month/4 ha	—	240	—	60
Loss due to feeding by Munia*/4 ha	—	19.0 kg	—	4.5 kg
Total loss/ha/season	4.75 kg		1.125 kg	

* 31 g/bird/day (Mathew, 1976)
** 75 g/bird/day (Saha and Mukherjee, 1978)

TABLE 4. Loss in the yield of paddy due to diseases and pests including birds during *khariff* 1980 and summer 1981.

	Expected yield (tons/ha)	Actual yield (tons/ha)	Estimated and extrapolated losses (in kgs/ha) due to						Actual loss
			insects[1]	diseases[1]	cold[1]	rodents[2]	birds[3]	Total	
khariff 1980	3.0-3.8	2.0	475	570	475	72	19	1611	1800
summer 1981	3.5-4.2	3.5	495	—	—	72	6	573	700

[1] Based on the data furnished by the Farm Superintendent, Main Research Station, U.A.S., Hebbal, Bangalore
[2] Sridhara & Krishnamoorthy (1978/79)
[3] Present study

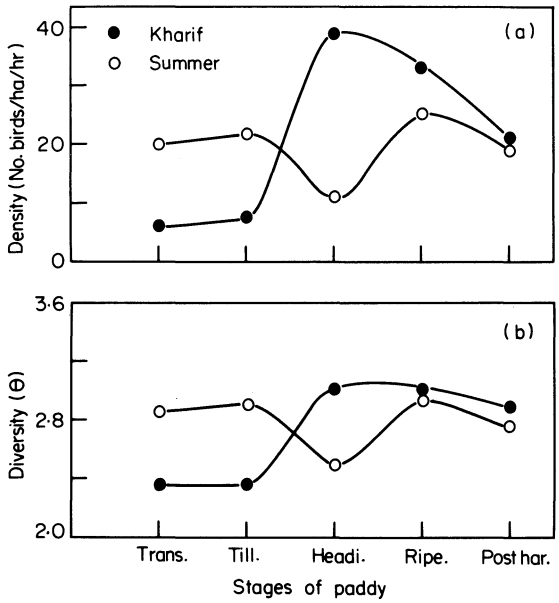

FIGURE 1. The density (a) and diversity (b) of avifauna seen at different stages of paddy growth.

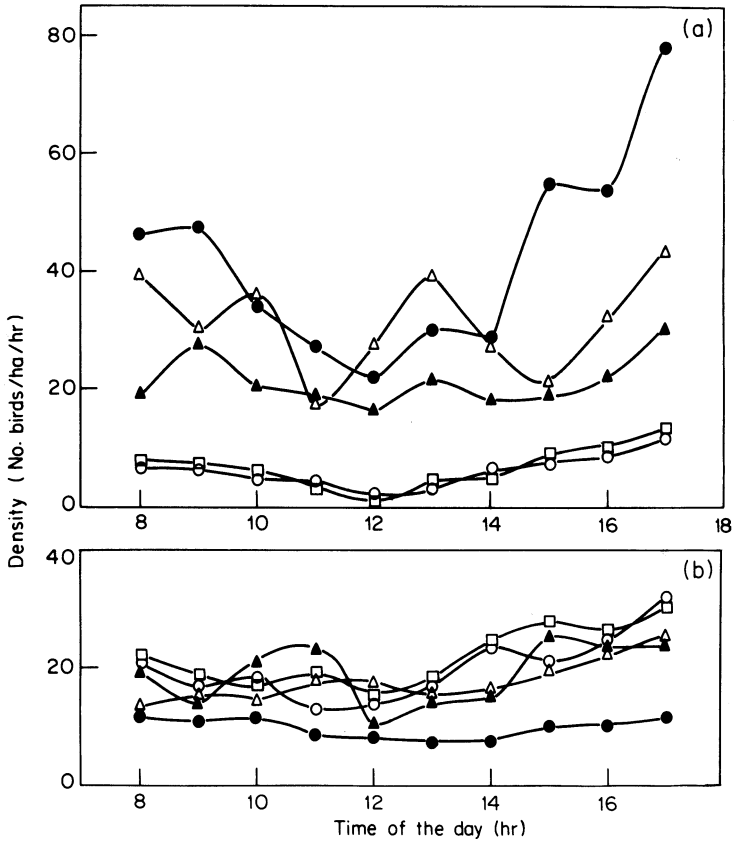

FIGURE 2. The density of birds seen at different hours of the day during the five stages of paddy growth for *khariff* (a) and summer (b).

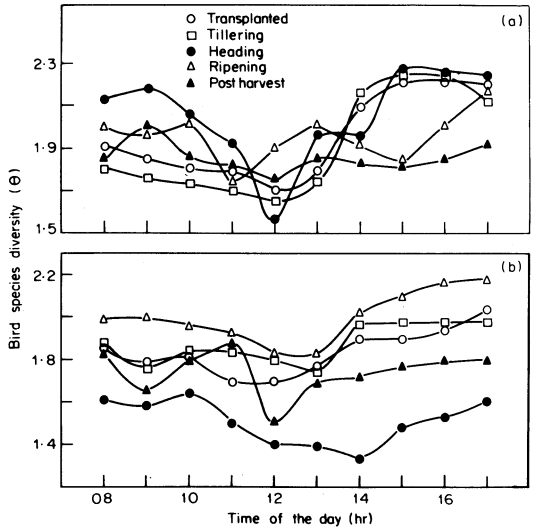

FIGURE 3. The diversity of birds visiting at different hours of the day during the five stages of paddy growth for (a) *khariff* and (b) summer.

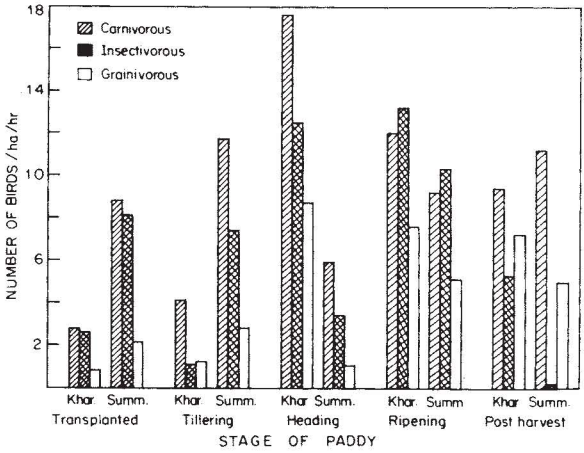

FIGURE 4. The half constructed (a) and fully constructed (b) nests of baya hanging down from coconut palms at the periphery of the study area.

FIGURE 5. A batch of munia feeding on ripe paddy.

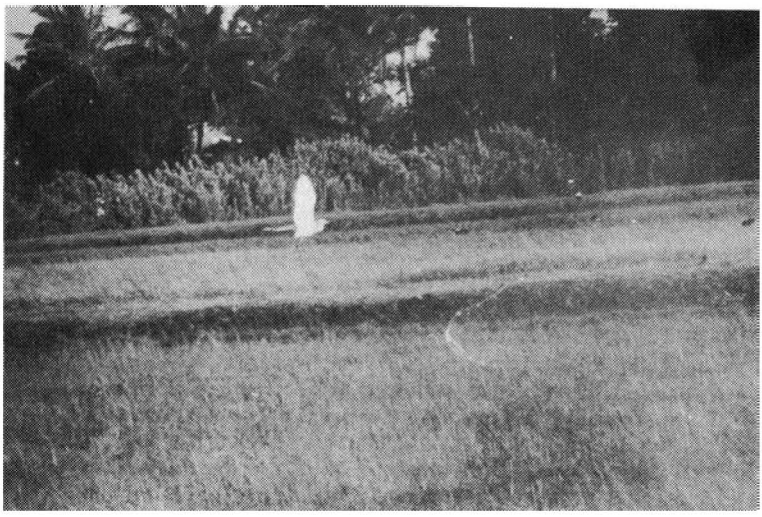

FIGURE 6. An egret flying over the study area with the coconut palms at the edge.