

**STUDIES ON BIRDS OF RICE FIELDS
WITH SPECIAL REFERENCE TO CERTAIN
PEST SPECIES**

By
S. SUBRAMANYA

**DEPARTMENT OF ENTOMOLOGY
UNIVERSITY OF AGRICULTURAL SCIENCES
BANGALORE
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**STUDIES ON BIRDS OF RICE FIELDS
WITH SPECIAL REFERENCE TO CERTAIN
PEST SPECIES**

By
S. SUBRAMANYA

Thesis Submitted to the
University of Agricultural Sciences, Bangalore
in partial fulfilment of the requirements
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in
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DEPARTMENT OF ENTOMOLOGY
UNIVERSITY OF AGRICULTURAL SCIENCES
Bangalore.

C E R T I F I C A T E

This is to certify that the thesis entitled "STUDIES ON BIRDS OF RICE FIELDS WITH SPECIAL REFERENCE TO CERTAIN PEST SPECIES" submitted by Mr. S. SUBRAMANYA, for the degree of DOCTOR OF PHILOSOPHY in AGRICULTURAL ENTOMOLOGY of the University of Agricultural Sciences, Bangalore, is a record of research work done by him during the period of his study in this University under my guidance and supervision, and the thesis has not previously formed the basis for the award of any degree, diploma associateship, fellowship or other similar titles.

September/6, 1987

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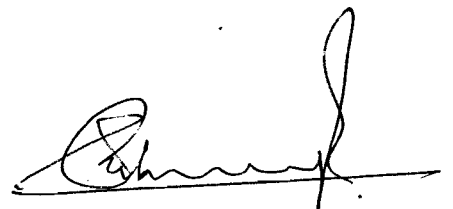
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INTRODUCTION

I. INTRODUCTION

Rice fields are not mere artificial habitats but appear to be extensions of marshy areas (Odum, 1963). Though monocultured, it provides a conducive environment for a variety of invertebrates and vertebrates (Ali and Ripley, 1968-74; Anon, 1976; Ayyar, 1940; Grist and Leaver, 1969; Gharpurley, 1944).

A lot of work has been carried out on the invertebrates, especially the insect pests of rice. But, systematic studies on birds and bird pests of rice is very meagre. However, reports are available on bird pests of rice from other countries (Grist and Lever, 1969; Anon, 1976).

Ali and Ripley (1968-74), Baker (1922-30), Jerdon (1862-64) and Whistler (1949) have made some passing reference on birds frequenting rice fields in India, without describing their ecological and behaviour patterns and processes. Other studies that have been carried out on birds in rice fields (Thirumurthi et al., 1981; Nathan and Rajendran, 1982) are only preliminary studies.

Several species of birds belonging to the families psittacidae and placeidae are considered as pests of paddy (Mathew, 1976; Dhindsa 1980; Mehrotra and Bhatnagar, 1979), and the distribution of many of the Indian birds vary greatly from one region to another within the Indian sub-continent both geographically and due to seasonality (Ali and Ripley, (1968-74). Hence, a bird considered as a potential pest

in one region may well be in doubt in some other region. Besides, in an era of changing land-use patterns and managements, one should expect new cropping systems to be vulnerable to the flexibilities of birds which had not assumed pest status before (Flegg, 1980).

Given such a situation, where detailed information on different species in a particular habitat is quite inadequate, it was felt necessary to gather sufficient basic information on each species, its identity, biology and ecology in relation to local climate and agricultural practices. This is of paramount importance in case of pest species, if one wishes to formulate sound management programmes (Ward, 1972, 1973; Dyer and Ward, 1977; Flegg, 1980).

Therefore, the present investigation was undertaken with the following objectives :

1. To study the species composition, status and utilization pattern of rice fields by birds,
2. To understand the seasonality and population fluctuations of bird community inhabiting the rice fields in the study area.
3. To study the food and feeding habits and activity pattern of bird pests in rice fields.
4. To study nesting habits of birds in rice fields.

* * *

REVIEW OF LITERATURE

II. REVIEW OF LITERATURE

2.1 Faunal Composition of Rice Fields :

Several cultural practices are followed in rice cultivation (Webster and Wilson, 1980) and these, according to Grist and Lever (1969) and Anon (1976) create different field types, coupled with varying stages of crop growth. According to Heckman (1979), prevalence of such a condition along with seasonal monsoon rains offers a congenial environment to a host of invertebrates and vertebrates.

Grist and Lever (1969) have recorded over 700 species of insect pests falling under nine orders and over 40 families, and 70 species of non-insect pests including mites, crustaceans, molluscs, nematodes and earthworms. Under vertebrate pests, they have listed 20 species of rodents, 65 species of birds and 10 species of fishes in rice fields all over the world.

A study on the rice field ecology was carried out by Heckman (1979) in Northeastern Thailand. Of the 589 species of biota recorded during the investigation, the rice field flora, comprised of 162 species of algae, fungi, pteridophytes, dicotyledons and monocotyledons. The rice field fauna included 422 species comprising protozoa, platyhelminthes, nematodes, rotifers, annelids, molluscs, mites, crabs, crustaceans, insects, fishes, frogs and snakes. Some mammals and birds were found to be associated with the aquatic rice field habitat. The birds observed at the study area were arbitrarily classified as temporary visitors, due to their wide-ranging wanderings.

Further, Heckman (1979) observed that the annual desiccation of the rice field habitat brought about by wet and dry climatic cycles required the aquatic rice field biota to be adapted to extreme physical annual agricultural cycle, which disrupts the aquatic community, first by the ploughing of the field and later by the harvest. Heckman (1979) opines that these stresses have led to the development of a well defined seasonal succession of dominant species of aquatic biota in rice fields of Thailand. He considers that this phenomenon has apparently come about as the result of a long standing regularity in the annual climatic and agricultural sequences of events which the archaeological findings have established to be at least 6000 to 7000 years in existence.

The snake, chequered Keelback (*Tropidonotus psicator*) is reported to be commonly seen in the paddy fields in India by Ghapurley (1944).

In the rice fields of Senegal River Valley, Africa, Collias and Collias (1970) have recorded monitor lizards *Varanus niloticus* and mammals like genets, *Genett senegalensis*; wild cats, *Felis sylvestris libyca* F. ; jackals, *Canis aureus* L. and the Egyptian mongoose, *Herpestes ichneumon* G. as being very common.

Over 100 species of insects; over 10 nematodes, about 23 rodents and 27 species of birds are recorded as occurring in rice fields in different parts of the world (Anon., 1976). Chatterjee and Dutta (1980 a, b) have recorded crabs *Paratelphusa hydrodromus* Herbst., and *P. spinigera*

Wood-Mason and Lymnaea snails (*Pseudosuccinea luteda* Lamarck, *Bellamya bengalensis* f. *typica* (Lamarck) and *Pila globosa* (Swainson) as common in West Bengal. According to them, crabs feed on rice nursery seedlings and newly planted ones, by cutting the basal regions of both tender seedlings and older plants and cause leaks in bunds and irrigation system due to their burrowing habit. Snails have been sighted feeding on *Azolla pinnata* during July to October months.

Similar view on the pestilence of crabs in rice fields has been held by Patel et al. (1955). In Madras crabs have been found damaging paddy. Jordon (1957) recorded five species of land crabs and 11 riverine crab species. In the later case the tidal influences resulted in heavy damage to paddy by *Sessarmia huzardi* Desm. Rice fields in river banks of Sierra Leone have suffered a similar fate by *Sarpatim* sp. (Anon., 1976).

Alam et al. (1980) have reported that the five striped squirrel *Funabulus pennati* Wroughton as an important rice pest, especially in deep water rice areas of Bangladesh. The squirrels feed on rice the way rats do.

Nine species of spiders belonging to six families have been recorded as predators of brown plant hopper infesting rice (Chatterjee and Dutta, 1979). The spiders namely, *Araneus* sp., *Neoscona theisi* (Walckenaes), *Lycosa* sp., *Pardosa annandalie* (Gravely), *Oxyopes* sp., *Marpissa* sp., *Marpissa decorata* Tikader, *Tetragnatha mandibulata*

(Walckenaer) and *Theridion* sp. are reported to prey on rice leaf hoppers, earhead bug and brown plant hopper.

Battish and Grover (1984) collected samples of aquatic fauna from the rice fields in and around Ludhiana and identified the species of Entomostraca. There were 2 conchostracans, 4 cladocerans, 15 ostracods and 6 copepods.

2.2 Birds frequenting rice fields :

The 89 species of birds frequenting rice fields reported by Ali and Ripley (1968-74), including herons egrets and bitterns (family Ardeidae - 8 spp); storks (Ciconidae - 2 spp.); ibises and spoonbills (Threskiornithidae 2 spp.); ducks (Anatidae - 5 spp.); kites and harriers (Accipitridae - 2 spp); cranes (Gruidae - 1 spp); rails (Rallidae - 5 spp); jacana (Jacanidae - 1 spp); plovers (Charadriidae - 5 spp); sandpipers, snipes, stints and ruff (Scolopacinae - 13 spp); painted snipe and stilts (Rostratulidae - 2 spp); tern (Laridae - 1 sp); dove (Columbidae - 1 sp.); parakeets (Psittaculidae - 3 spp); cuckoos (Cuculidae - 1 sp); kingfisher (Alcedinidae - 1 sp.); larks (Alaudidae - 2 spp); swallows (Hirundinidae - 3 spp.); drongo (Dicruridae - 1 sp.); mynas (Sturnidae - 2 spp); crows (Corvidae); chats (Turdinae - 1 sp.); pipits and wagtails (Motacillidae - 5 spp); weaverbirds and munias (Ploceidae - 3 spp); munias (Estrildinae - 6 spp); finches (Fringillidae - 1 sp) and buntings (Emberizidae - 4 spp). Rice field is considered to be one of the several habitat types that these birds frequent within Indian limits. However, with the exception of a few species

mentioned as feeding in rice fields, details on the activity patterns of other species is wanting.

Thirumurthi et al. (1981) have recorded 26 species of insectivorous birds frequenting the rice fields in Madurai. The list includes swifts (*Apus* spp.), bee-eaters (*Merops* spp.), roller (*Coracias benghalensis* (L)), drongos (*Dicrurus* spp.), myna (*Acridotheres tristis* (L)), tree pie (*Dendrocitta* sp.), crows (*Corvus* spp.), ^{Redvented}bulbuls (*Pycnonotus cafer* (L)), ^{Common}babbler (*Turdoides caudatus* (Dumont)), flycatcher (*Terpriphone paradisi* (L)), wagtail (*Motacilla alba* (L)), koel (*Eudynamis scolapacea* (L)), nightjar (*Caprimulgus asiaticus* (Latham)), several herons, bitterns and egrets (*Ardeidae*), woodpecker (*Dinopium benghalense* (L)), a sunbird (*Nectarinia asiatica* (Latham)) and the peafowl (*Pavo cristatus* (L)). Among the birds observed, drongo, myna, swift, roller and the pond herons have been reported as useful birds in the natural control of rice pests. Nathan and Rajendran (1982) have observed varying degrees of commonness, rarity and seasonality among 35 species of birds occurring in rice fields. They agree with the findings of Thirumurthi et al. (1981) that the birds are important predators of rice insect pests. Sridhara et al. (1984) have recorded 32 species of birds visiting rice field in Bangalore. Some of the species recorded by them in addition to those of Thirumurthi et al. (1981) and Nathan and Rajendran (1982) are the pariah kite (*Milvus migrans* (Boddaert)); pied crested cuckoo (*Clamator jacobinus*) blackheaded cuckoo shrike (*Coracias melanoptera* (Ruppell)); dabchik^c (*Pediceps ruficollis* Pallas); coppersmith (*Magalaima haemacephala* (Muller)) and purple sunbird

(*Nectarinia asiatica*). They have reported some observations on the density, diversity and foraging habits of birds.

2.3 Birds as pests of rice :

Efferson (1952) considers that bird damage to rice is the greatest retarding factor to expanding world production of rice. The birds damage rice in the field at the time of germination and at earhead stage. Sometimes, at certain times rice crop during its early stage gets badly trampled by migratory waterfowl, which are attracted in large numbers to inundated rice fields in otherwise dry regions (Anon., 1976).

2.3.1 Weaverbirds :

Blackfaced diochs (*Quelea quelea* (L)), the red billed, sparrow-like birds are very serious pests in all dry regions of Africa south of Sahara (Grist and Lever, 1969). They are associated with the grassy steppe, dry savanna and montane regions - areas with a short growing season producing quick growing grasses, bearing small seeds on which *Quelea* relies for most of its food. The birds are known to congregate in enormous flocks, the number of which may range upto 200 million as was a case of Senegal Valley in 1953 (Grist and Lever, 1969). They report the presence of three different races of *Quelea* in Africa represented in West, North-east and South Africa. The village weaverbird, *Ploceus cuculatus* (P.L.S. Muller) is known to be another serious pest of rice in Africa (Anon., 1976).

Several ploceids (*Euplectes afer* Gmelin, *E. orix* (L) and *E. hosdacea* (L.), *Ploceus cuculatus*, *P. capitalis* Latham *P. erythropus* (Hastlans) are known to cause a steady and serious loss to rice crop throughout the wetter parts of West Africa and probably also in other parts of African continent (Grist and Lever, 1969).

In Asia, of the several species of weaverbirds known to be pests of rice, the baya (*Ploceus philippinus* (L)), Finn's baya (Horsfield) are considered as serious pests (Ali and Ripley, 1968-74; Saha and Mukherjee, 1978; Mathew, 1976; Ali et al., 1978). With the exception of the second species the other two are widely distributed in India. the baya is also a serious pest of rice in West Malaysia (Avery, 1981). *Ploceus atrigula* (Hordgson) the common weaverbird, is a serious pest of rice in upper Burma to Thailand, Combodia, Laos, Vietnam and Indonesia (Dammermann, 1929).

2.3.2 Sparrows, Munias and Other finches :

House Sparrow (*Passer domesticus* (L)) has a worldwide distribution and is considered an important pest of field crops, mainly cereals and millets (Kendeigh, 1974). In India, in addition to the resident race (*P. d. indicus*) there are two other races (*P.d. bactrianus* Zarudny & Ked and *P.d. parkini* Whistler). These migrate to different parts of India from Russia and Himalayas and inflict heavy damage to rice (Ali and Ripley, 1974; Ali, 1963).

Grist and Lever (1977) state that the tree sparrow **Passer montanus** L., is widespread over Europe, North Africa and Asia. Though it feeds mostly on fruits, small seeds and insects, it is occasionally seen feeding on ripe rice. According to Otones and Sison (1949) tree sparrow is an introduced species in Philippines where it is abundant in and around towns. Occasionally it visits paddy fields in flocks of considerable size. Its activity in Philippines is known to coincide with harvesting of rice when it feeds on the ripened grain (Anon., 1976).

Java Sparrow (**Padda oryzivora** (L)) cause some damage in paddy fields in the Malaya Archipelago, where it may sometimes be seen in large flocks (Dammermann, 1929).

Several species of estrildrids (Waxbills or grass finches) may become pests locally throughout southeast Asia (Anon., 1976). According to Dammermann (1929) **Lonchura (Munia) Jagori** (Fab.) is a common species in the Philippines where it occurs in large flocks. It is gregarious and large groups of nests are found in the months of May and June among tall grasses, shrubs and palms. **Lonchura (Munia) ferruginia** causes damage in Luzon, Philippines. In addition **Lonchura (Munia) maja** (L) and **Lonchura (Munia) punctulata** (L) are known to be destructive (Dammermann, 1929).

These munias according to Grist and Lever (1969) are distributed in India, Southeast Asia and the Philippines. They cause enormous damage to paddy crop, in which they may be found in large flocks eating the

grain. They are known to move from field to field as the crop ripens and the longer the period over which the harvest extends, the more broods of these birds may be expected.

In a field study at Ludhiana, Dhindsa and Toor (1980) observed that as much as 40.99 per cent of damage to sown seeds of rice was caused by baya (*P. philippines*) blackthroated weaverbirds, (*P. benghalensis*), streaked weaverbirds (*P. manyar*), house sparrows (*P. domesticus*) and spotted Munias (*L. punctulata*).

At Maruteru in West Godavari District, the bird damage ranged from 0.64 to 13.50 per cent at dough stage due to Indian baya (*P. philippines*), munias (*Lonchura* spp.), house sparrows (*P. domesticus*) and roseringed parakeet (*P. krameri*) (Raj and Shivanarayan, 1980).

During a study carried out on the bird pests of rice at Bumbong Lima, Province Wellesley, West Malaysia, Avery (1981) found the principal rice-eating species to be four species of munias (*Lonchura* spp.) and the baya weaver (*Ploceus philippines*). The four species of munias in the order of importance were the sharptailed munia (*Lonchura striata* (L)); the spotted munia (*L. punctulata*); the chestnut munia (*L. malacca* (L)) and the white-headed munia (*L. maja*). The sharptailed munia was the most numerous of the four species recorded.

2.3.3 Blackbirds :

Grist and Lever (1969) states that in various parts of United

States and elsewhere, the blackbirds (*Agelaius* spp.) severely damage to the rice crop by pulling up seedlings - apparently for the purpose of eating the remnants of the kernels, and also eating the ripening and ripe rice grains in the field.

Neff and Meanly (1957) made a close study of these blackbirds in Arkansas and assessed the damage to be about 1.5 million dollars per year. The redwinged blackbird (*Agelaius phoeniceus* (L)) comes from northern nesting grounds into Grand Prairie in October and returns in March. Varillero (*Agelaius ruficapillus* (Vieillot)) is known to be a plague in the paddy fields in Santa Fe, Argentina.

Other species known to cause damage to rice are cowbirds, *Molothrus ater* (Bodd.); the bronzed grackle, *Quiscalus aeneus* Ridgway; brewer's blackbird, *Euphagus cyanocephalus* (Wagler); rusty blackbird, *E. carolinus* (P.L.S. Muller) (Grist and Lever, 1969).

Orians (1980) states that before the beginning of cultivation redwinged blackbirds lived in large colonies in river valley swamps, many of which have now been reclaimed for rice growing. As a result, although the natural feeding areas have been reduced the birds have been provided with acceptable substitute. The flooding of the stubble fields, for duck hunting has provided the blackbirds with an alternative habitat for much of the year and in 1959 even resulted in a second autumnal breeding season.

In Surinam occasional damage is caused by redbreasts (*Leistes m. militaris* (L)), Yellow-headed marshbirds (*Cacicus c. cela* (L)) and spurwings or Jacanas (*Jacana spinosa jacana* (L)) (Wouters, 1963).

2.3.4 Cockatoos and Parrots :

In the Northern Territory of Australia, costly damage to the rice crop is caused by large flocks of cockatoos especially corella or parakeet *Kakatoe tenutrostris* (Kuhl.) that attack rice crop with nearly mature grain (Wilson-Jones, 1963). Also, In New South Wales the galah or rose breasted parrot (*Cacatua galerita* (Lath)) is known to cause wide spread damage to rice crop. According to Kuwayama (1948) in nurseries or in fields wherever direct seeding is followed, corellas dig up and eat paddy seed without any apparent ill-effects from the mercurial BHC seed dressing.

Roseringed parakeet (*Psittacula krameri* (Scopoli)) is the most widespread abundant and destructive pest on rice crop in India, Burma and Sri Lanka (Anon., 1976). In Vietnam parrots are reported to be the most destructive to quick growing rice varieties and in cultivated areas adjacent to wasteland (Anon., 1976).

2.3.5 Ducks and other waterbirds :

In Guyana, pregerminated sown paddy was found to be particularly susceptible to very severe damage by wild ducks (*Pterocynaea discors* (L.)) in the first two weeks after sowings (Giglioli, 1958). He also found

that the vulnerability of seed attacked depended on the depth of water in the field. Absence of water or water depth in excess of 4 to 5 inches prevented the ducks from feeding, while depths of 1 to 4 inches regarded as optimum for seed establishment was the most suitable to the birds feeding habit. The ducks nocturnal in habit fed on young and tender plants.

The wis-wissi duck. *Dendrocygna autumnalis discolor* Sclater and Salvin alight in flocks of several hundreds in newly sown rice fields in Surinam (Wouters, 1963). They damage the crop by treading down young seedlings. The water fowl, *Porphyryla maritunica* (L), a bird resembling a moorhen, also causes damage to standing paddy in Surinam.

In Thailand, whistling teal *Dendrocygna javanica* (L.) is reported to be an important pest of rice. These nocturnal birds move about locally during the day, around marshes, flooded marshes and open water habitats. By sunset, they fly over to paddy fields for foraging (Ratana-worbhan, 1982). In addition to feeding on rice grains the birds are known to damage the crop by stepping on rice stalks.

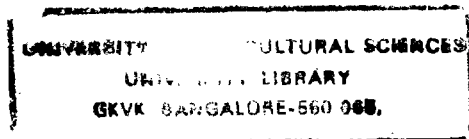
In the northern territory of Australia, the magpie goose (*Anseranas semipalmata* Latham) causes damage annually by feeding on wild rice and swamp grasses and hinder the establishment of paddy crop in the northern territory of Australia (Longfield and Moir, 1961). A subsequent survey established that only a small proportion of the geese attack the crop and that the number of geese will not increase as the rice area increased (Anon., 1958).

Ali and Ripley (1968-74) while dealing with Anatidae in their Handbook (Vol. I), mention that the spotbilled duck (*Anas poecilorhyncha* J.R. Forster), the mallard (*A. platyrhynchos* Linnaeus), gadwal (*Anas strepera* Linnaeus); wigeon (*A. penelope* L.) and the garganey (*A. querquedula* L.) frequent squelchy paddy fields. They mention that these ducks are nocturnal in habit. They are known to spend the entire day in jheels or irrigation tanks and fly out at dusk to feed in outlying paddy fields.

In New South Wales, the coot (*Fulica atra* L.) and the black coot (*Porphyrio melanotus* Temminck) are responsible for much damage, but still higher damage is caused by wild ducks - the black duck (*Anas superciliosa* (Gmelin), wood duck (*Chenonetta jubata* (Latham)) and the grey teal (*Virago gibberifrons* (S. Muller)). Other birds which cause minor damage include the black moorhen (*Gallinula tenebrosa* Gould) and the waterhen (*Microtribonyx ventralis* Gould) (Longfield and Moir, 1961).

The following birds found in Australia also occur in New Guinea, where rice is damaged by migrants from Australia. The bald coot, *Dendrocygna guttata* Schlegel, *D. arcuata* (Horsfield), *Anas superciliosa* (Gmelin) and *Anseranas semipalmata* Latham are the important pests with the last species causing the maximum damage.

Grist and Lever (1969) mention that the Egyptian goose *Alopochen aegyptiacus* (L), a resident in African rice fields tramples large areas of growing rice. They also mention the damage caused to rice by white



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facéd tree-duck. *Dendrocygna viduata* (L) in Africa wherein in addition to eating young rice plants they are known to foul up the water in flooded fields thus making it unfit for rice growing.

2.3.6 Other birds :

Mehrotra and Bhatnagar (1979) while reviewing the status of economic ornithology in India, find that out of the possible 143 species of bird pests within Indian sub-continent only about 29 species damage rice. Rest of the species inflict damage to crops such as millets, fruits and other cereals. The major groups according to their analysis include- pigeons and doves (5 spp.); parakeets (3 spp.), mynas (4 spp.); crows (1 spp.), sparrows (2 spp.); weaverbirds (4 species); munias (3 spp.); other finches (2 spp.), and buntings (5 spp.). Further according to them only 16 out of the 29 species recorded are known to be the pests of rice in the peninsula.

Brown (1969) reports a number of bird pests in the rice growing provinces of Venezuela and Peru, the wild pigeon (*Columbo fasciata* Say); turtle dove (*Eupelia cruziana* Prevost), the thrush (*Molothrus bonariensis occidentalis* Gmelin), paddy bird (*Geothlypis aequinoctalis auricularia*); large egret (*Egretta (Casmerodius) albus*) lesser egret (*Egretta (Leucophoyx) thula* Molina), the dove (*Columba maculosa albipennis* Temminck), a paraquete (*Psilopsiagon aurifrons* Ruppell) and a wild duck (*Sarcidiornis melanotus carunculata* (Pennant)).

Starlings (*Sturnus vulgaris* L.) introduced into the United States from Europe in the last century, is now widespread. Between October and March flocks of 10,000 or more birds may sometimes be seen working over stubble covered fields (Neff and Meanly (1957).

2.4 Food habits of birds frequenting Rice field :

While studying the food habits of birds, Mason and Lefroy (1912) have collected information on birds which were either feeding in rice fields or those having their food taken from rice fields. The food found in the stomachs of the birds that they collected included either rice grains or insects inhabiting rice fields or a mixture of both. They found pond herons and cattle egrets feeding on earthworms, grasshoppers (*Chrotogonus* sp.) frogs, crabs and other aquatic insects in the ducks. Nakta, whistling teal, gadwal, common teal and bluewinged teal feeding on wild as well as cultivated rice. Of these the nakta's stomach was found to be full of rice and they quote of an instance of bluewinged teals arriving in rice fields in great numbers and destroying acres of crop at one visit. Several species of birds, namely, the roller (*Coracias benghalensis* L.) hoopoe (*Upupa epops* L.), house crow (*Corvus splendens* Viellot), jungle babbler, drongo and the common myna (*Acridotheres tristis* L.) were found to be feeding on *Chrotogonus* sp., *Brachytripes achatinus* (Stoll), *Gryllotalpa africana* (P.de Beauv.). The bengal florican (*Eupodotis (Syphotis) bengalensis* (Gmelin)) feeds on the inflorescence of paddy during October and November. In rice fields close to forests, the red jungle fowls (*Gallus ferrugineus* L.) often make raids to feed on rice near harvest times.

Rails usually feed on small molluscs; insects and their larvae and seeds of water plants (Mason and Lefroy, 1912). Some of the rails such as the purple moorhen (**Porphyrio porphyrio** (L.)); blue-breasted banded rail (**Rallus striatus** (Swainson)) and baillon's crane (**Porzana pusilla** (Pallas)) are known to feed on rice grains, which adds to the mixed diet of these species. Rails keep moving about rice fields (Mason and Lefroy, 1912).

Mason and Lefroy (1912) examined ~~the~~ stomach contents of three spotted munia (**Lonchura punctulata**) and found two injurious insects in one but all of them had weed seeds. They further remarked that this species does some damage to grain especially paddy, but a large percentage of their food in all probability, consists of small weed seeds and rarely insects.

Saha and Mukherjee (1978) found in their gut analysis of black-headed munia (**L. malacca**) and spotted munias (**L. punctulata**), vegetable matters of which about 42 per cent consisted of paddy grains and 36 per cent of seeds of bamboo and other weed grasses. There was 17 per cent of grit and only about one per cent of animal matter.

Mukherjee and Saha (1974) studied stomach contents of (56 adults and 84 chicks of) common baya (**P. philippinus**). They observed that, in the case of very young chicks (3-6 day old), the stomachs consisted mainly of weed seeds (Graminae) and a number of minute stone chips. In some cases, a few broken molluscs-shells were also found. As the

chicks grew-up (7-10 days) a change of food was noticed. The contents were mostly insect fragments and the intake of molluscs shells increased. The insects were mostly nymphs of orthopterans. At the fledgeling stage a few soft rice grains were traced. In the stomachs of non-breeding adults and breeding males consisted mostly of rice grains and in a very few cases insects were also present.

Mathew et al. (1978) studied the food habits of pond heron, spotted doves, little brown doves, and the black drongo from Cudappa (A.P.) and Calicut (Kerala). The food of pond herons consisted mainly of crabs, nymphs of dragonflies, grasshoppers and tadpoles. In the stomach of a single pond heron, 161 leeches (*Herpolodelloider* sp.) were found. In the stomachs of doves paddy grains were most frequent. In a stink-bug (*Leptocorisa acuta* (Thunberg)) infested rice field at Phalghat District, black drongoes made 72 attacks on the bug within 80 minutes. In the stomachs of 9 birds analysed on that day 160 heads of *Leptocorisa* were counted.

Mukherjee (1963-73) studied the food habits of 24 species of birds, in 24-Parganas District, West Bengal, India, of which 8 species frequented paddy fields. Part of the diet of these birds comprised of invertebrates inhabiting rice fields. The stomach of the Little Green Heron (*Butorides striatus* (Bonaparte)) contained *Chrotogonus* sp. and *Acrydium* sp. taken from paddy nurseries.

The gut contents of the pond heron (*A. grayii* (Sykes)) common in inundated paddy-fields consisted small frogs (*Rana limnocharis* Wiegmann), crabs (*P. jacquemontii*) and insects like (*Chrotogonus* sp., *Attractomorpha* sp., *Oxya* sp. *Acrotylus* sp. *Acrydium* sp. and *Laccotrephes* sp. (a nepid). The stomach contents of pond herons on the whole had 7.50 per cent insects, 23.5 per cent crustacea and 16 per cent of amphibia. The food habits of *Ixobrychus cinnamomens* (Gmelin), frogs (*R. limnocharis*), grasshoppers (*Acrotylus* sp., *Acrydium* sp., *Chrotogonus* sp.), nepids (*Laccotrephes* sp.) was more or less similar to pond heron.

The stomach of cattle Egrets (*Bubulcus ibis* (Boddaert)) contained 69.84 per cent of insects. This included several insect pests of paddy (namely, *Hieroglyphus banian* Fabricius, *Acantholobus* sp., *Acrotylus* sp., *Heteracaris capensis* Thunberg, *Iurida buremeister*, *Menida histria* Fabricius, *Leptocorisa acuta* Thunberg; *Tettigoniella* sp. *Nephotettix bipunctatus* Fabricius *Deltocephalus* sp., *Phyllognathus dionysius* (Fabricius), *Mylabris* sp., *Gnathospastoides rouxi* Castalenan, *Cylindrothorax ruficollis* (Fabricius), *Epicuta* sp., *Cantharis* sp., *Dicladispa armigera* Oliver, *Leptispa pygmoea* Baby; *Mylocyrus* sp. *Atheraeuta oryzae* Marshall, *Echinocnemus oryzae* Marshall, *Spodoptera mauritia* Boisduval (larva), *Cirphis* sp. (larva), *Nymphula* sp. (larva) and *Pelopedis mathias* (Fabricius) (larva).

The stomach of smaller egrets, (*Egretta intermedia* (Wagler)) frequenting shallow inundated paddy fields, contained several orthopteran, dipteran, coleopteran and lepidopteran pests of paddy. The pests found

in the stomachs included *Hieroglyphus banian*, *Criotellix* sp., *Loxilobus* sp., *Acrotylus* sp., *Attractomorpha crenulata* Fabricius, *Chrotogonus* sp., *Spodoptera mauritia* Boisduval (larva), *Nymphula depunctalis* Guenee (larva), *G. rouxi*, *C. ruficollis*, *Epicuta* sp., *D. armigera*, *L. pygmoea*, *Mylocerus* sp., *Paramecops* sp., *A. oryzae*, *E. oryzae*, *Pachydiplasis oryzae* Marshall, *Atherigona* sp.

Little egrets (*Egretta garzetta* (Linnaeus)) contained *H. banian*, *Criotettix* sp., *Acrydium* sp., *A. crenulata*, *Chrotogonus* sp., *Migratoria migratorides* (Reiche and Fairmaire), *Gryllotalpa* sp., *S. mauritia* (larvae), *Agrotis* sp., *Cirphis* sp., *Schoenobius incertellus* Walker, *N. depunctalis* (larvae), *P. diomysius*, *G. rouxi*, *C. ruficollis*, *Oides affinis* Jacoby, *L. pygmoea* and *D. armigera*.

Rice fields were one of the foraging sites for openbill storks *Anastomus oscitans* (Boddaert) at Sundarban, 24-Parganas District. In addition to other vertebrates and invertebrates, these storks feed on crabs, (*Paratelphusa jacquemonti* (Rathbun)) and mole crickets (*Gryllotalpa* sp.).

The food of redwattled Lapwing (*Vanellus indicus* (Boddaert)) consisted of several species of insects namely, *H. banian*, *Attractomorpha*, *Oxya* sp., *Chrotogonus* sp., *Acrotylus* sp., *Heteropternis* sp., *Locusta danica* Linnaeus, *Pyrgomorpha* sp., *Gryllus* sp., *Liogryllus* sp., *Acheta bimaculata* (De Geer), *Brachytrypes* sp., *Leptocoris* sp., *Nephotettix* sp., *G. rouxi*, *C. ruficollis*, *C. tenuicollis*, *Epicuta* sp., *O. affinis*, *D. armigera*, *Mylocerus* sp., several spiders found in paddy fields namely, *Leucage decorata* (Blackwall), *Araneus* sp., *Ecuta javanica* Thorell, and

a snake, **Xenochrophis piscator** (Schneider).

The stomach of spotted sandpiper (**Tringa glareola** Linnaeus) contained two of the insects (**Acrydium** sp. and **Chrotogonus** sp.) known to be the pests of paddy.

The food habits of baya were studied during an investigation on the ecology of baya weaverbird (**P. philippinus**) by Mathew (1976) in Rajampet Taluk, Cuddapah District of Andhra Pradesh. He found that 65.0 per cent of the food taken comprised of paddy while the rest, excluding 3.2 per cent of insects, was made up of grass and minor millet seeds. Among the grass seeds **Echinochloa colonum** (L.) Link and **E. crusgalli** (L.) P. Bœur were prominent. The diet of nestling baya contained nearly 53 per cent of insects, 11.8 per cent spiders and 9.1 per cent grains. Among the insects fed to the nestlings, grasshoppers (**Oxya velox**, **Epacromia dorsalis**, **Tryxalis turrita**, **Conocephalus** sp., **Chrotogonus** sp., **Acrydium** sp.), crickets (**Trydactylus** sp., **Gryllus** sp. and caterpillars (**Boaris** sp., **Ismene** sp., **Papilio** sp.) predominated.

In the rice fields of Guyana, South America Snail Kites (**Rostrhamus sociabilis** Vieillot) is a common bird of prey. This kite feeds exclusively on snails (**Pomacea** sp.) which are found abundantly in the rice fields. (Bessinger, 1983). According to him, the kites number was highest when rice fields were drained and not planted with rice. As irrigation and rice growth increased the kites use of rice fields decreased.

Ali et al. (1978) examined 55 birds for their gut contents, of which baya (*Ploceus philippinus*) constituted 49.09 per cent, which fed only on rice grain. The remaining had millets, weed seeds, molluscan shells and insects.

Avery (1980) found in addition to rice grain, filamentous green algae *Spirogyra* in the stomachs of Sharp-tailed munia (*L. striata*) in West Malaysia. Rice was the most common food of spotted munias (*L. punctulata*) in the field, but they were also seen frequently eating *Echinochloa*, a common weed grass that was abundant at certain times of the year. Spotted munia also eats algae, but not so often as did the sharp tailed munia. Baya weaverbirds were never seen eating algae. Rice comprised the bulk of their diet.

In Arkansas, Neff and Meanley (1957) have made an interesting and valuable assessment of the status of red-winged blackbirds. They found that vegetable substances comprise of 80 per cent of the food of the redwinged blackbirds (*A. phoeniceus* (L)); rice made up 45 per cent of this total and wild grasses 23 per cent of total materials consumed. Animal foods, largely insects, comprised 19.3 per cent which included army worms cutworms, grasshoppers, stink bugs, weevils and other beetles.

2.5 Activity pattern of birds in rice fields :

According to Ali and Ripley (1968-74) most of the herons, egrets, storks and ibises prefer feeding in inundated ploughed paddy field where freshly turned up soil provides ample food. In contrast,

bitterns and cattle egrets in addition to ploughed fields, prefer inundated standing paddy fields. Ducks (Anatidae) which usually spend the day time in irrigation reservoirs, irrigation tanks, would fly-out at dusk to feed in paddy fields at night in squelchy paddy fields. Rails again are known to spend their time in irrigated fields, while plovers frequent partially inundated fields, sandpipers and snipers are considered partial to marshy paddy fields with puddles dotting here and there. The snipes prefer squelchy harvested fields. Stilts frequent inundated, ploughed fields; Doves and parakeets frequent paddy fields during harvesting stage to feed on grains. Larks prefer paddy stubble and plowed fields.

Warblers are known to frequent fields with standing rice. Of the several warblers, the streaked fantail warbler (*Cisticola juncidis* Whistler) is considered to be very common in paddy fields and according to Ali and Ripley (1968-74) the paddy fields have attracted the species to Himalayas where they inhabit exclusively in paddy fields.

Chats (Turdinae) have been observed to frequent fallow paddy fields bordered by lantana thickets and gardens in village precincts. Pipits are known to affect dry paddy fields. Wagtails feed either in wet or squelchy march rice fields. Sparrows, weaverbirds and munias come only to feed on grains and buntings on the other hand are known to affect rice stubbles or feed on margins of paddy fields.

In a study conducted by Sridhara et al. (1984) it was observed that the density and diversity of birds was maximum in the summer season when the grain was ripening. Minimum density and diversity

was seen at heading stage. Both these parameters were less at transplanting and tillering stages of kharif crop but was more in the subsequent summer crop. Further, they grouped birds based on their foraging behaviour. According to them the carnivores included egrets, heron, plovers, kingfishers, kite, lapwing, stilt and dabchicks. Excluding the first three, all others were solitary in habit. Among the insectivores myna, sparrow, swallow, swift and warblers were flock feeders, with swallow and swifts being aerial feeders. The drongo, roller, wagtail, cuckoo, cuckoo-shrikes were solitary. 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. The granivores included bayas and munias which perched on paddy plant while feeding. Parakeets were observed feeding directly from plant, while the pigeon and doves picked up grains fallen on the ground.

Thirumurthy et al. (1979) while studying the insectivorous birds associated with rice fields observed that the black drongos (*Dicrurus adsimilis* Vieillot) usually perched on some convenient perch and captured their prey by sudden gliding sweeps. Common mynas (*A. tristis*) always searched the ground for prey and were active throughout the day more in non-cropped areas and harvested fields. Crows were active at the time of ploughing and after harvest.

During their study Mathew et al. (1979) observed that pond herons affected paddy fields at all stages of the crop but more often young fields or stubble fields with water and those being prepared for

planting. The species fed solitarily during day time and at dusk collected in large flocks to roost on tree in villages. The pond herons fed by walking slowly through the rice fields and watching the ground carefully. Black drongoes frequented paddy fields in flocks of upto 16 birds at all stages of cultivation. When paddy is being harvested drongoes fed in close association with common myna capturing the insects flushed out by the latter. Common mynas usually moved in groups up to sixty and fed from ground, in ploughed fields, stubble fields. Large pied wagtails (*Motacilla maderaspatensis* (Gmelin)) was observed in muddy inundated paddy fields or on the grass covered bunds.

According to Saha and Mukherjee (1978) the blackheaded munia and spotted munia, in the company of the baya invaded paddy nurseries as well as the standing crop. These birds flocked in hundreds from nearby sugarcane fields, bamboo thickets and tall grass growing in marshes. They made frequent trips during the whole day from sugarcane and bamboo thickets to the nursery and standing crop of paddy. They were observed moving in flocks from one area to another invading crop and grasses in flower.

A survey of paddy fields in and around Maruteru (W. Godavari District) (Anon., 1979) revealed that birds namely, roseringed parakeet (*Psittacula krameri*), house sparrow (*Passer domesticus* Jardine and Selby), baya weaverbird (*P. philippinus*), streaked weaverbird (*P. manyar* Lesson), spotted munia (*L. punctulata*), Whitethroated munia (*L. malabarica* (L)) and blackheaded munia (*L. malacca* (L.)) feeding on rice grains in different

stages. It was found that, the parakeet, sparrow, baya and spotted munia fed on the exposed or germinated seeds sown in the field. During seedling stage certain waders (identity unknown) trampled and ate the young seedlings. Sparrows, weaverbirds and munias were seen invading the standing rice crop during milky stage to crush the developing grain and feed on the milky content. During dough and mature grain stage weaverbirds, munias, sparrows and parakeets were seen feeding on the grains. Parakeets were observed removing the entire earheads from the standing crop. In addition to feeding, grain loss also occurred ^{due} to shaking of loose grains from panicle.

During a study of the ecology of baya weaverbirds (*P. philippinus*) Mathew (1976) investigated the feeding habits, behaviour, breeding, seasonal and local movements in the rice growing areas of Rajampet in Andhra Pradesh. The bayas, residents in the cultivated parts of Rajampet, bred from mid April these birds were met with flock sizes of less than 200. They fed on freshly sown seeds and/or standing crops of paddy and millets from milky stage onwards. They fed in two distinct sessions one from about 6.00 to 9.00 hrs and another from 15.00 to 18.00 hrs. The hotter parts of the day was spent in shady mango orchards and beetle vine gardens. From such perching sites the birds dropped surreptitiously into the ungaarded parts of the field with mature crop. After feeding for about 15 minutes they returned back to these shady vegetation.

Bayas roosted during nights in sugarcane fields, scrub jungles and reeds. They used the same roosts between intervals of four days

to two years. However, bayas were found to change roosts within a single year. Bayas ringed at breeding colonies showed that the breeding birds did not move very far and possibly bred in the same area. Ringing and subsequent retrapping showed that bayas moved about locally within a distance of 2-5 km from its breeding area.

Attacks on standing crop of paddy by bayas was more frequent in rice fields situated close to mango orchards and concealed by the thickets of lantana, ber and neem bordering rice fields. Further, Mathew (1976) found that bayas exploited the local layout of crops very efficiently, particularly the combination of paddy and millets with sugarcane and beetle vine grown nearby. The latter crops provided ideal roosts and places of assembly and refuge for the birds. When the sugarcane was cut the movements of baya was disorganized and were forced to roost in less safe places like scrub jungles and reeds (Mathew, 1976).

Dyer et al. (1977) observed that redwinged blackbirds (*A.phoeniceus*) occupied a variety of upland field habitats as well as low-lying wetlands or marshes. Following breeding, the birds assembled in large roost aggregations, it was during this post breeding roosting phase the agriculture impact of the birds was most severe. These post-breeding concentrations gathered in the marsh to roost and from these roost epicenters they ranged radially outwards to forage in vast areas of crop fields and the mono-culture practices restricted foraging to these fields (Wiens and Dyer, 1975). Further, the roosting redwinged blackbirds dispersed from and returned to the roost concentration daily.

Hamilton and Gilbert (1969) assumed a linear dispersion of starlings (*S.vulgaris*) from the roost epicenter, with population density decreasing with increasing distances from the roost.

According to Gadgil and Ali (1975) the baya weaver bird (*P. philippinus*), blackthroated weaverbird (*P. benghalensis*) and Streaked Weaverbird (*P. manyas*) from large communal roosts throughout the year. These roosts may be pure or mixed with other species, including migrant swallows and wagtails.

A large roost of spotted munias (*Lonchura (Uroloncha) punctulata*), whitebacked munias (*L. (Uroloncha) striata*), and common weaverbirds was observed by Warth (1953) in Sakleshpur. The roost was located in a dense lantana thicket close to paddy fields bordering the Hemavathi River. Flocks of ten to forty birds arrived in rapid succession for about half an hour preceding dusk. The congregation of several thousand birds carried on a noisy twittering, with much shifting of positions, before settling down for the night.

During a study carried out at Ludhiana, Dhindsa and Toor (1981) recorded that the three weaverbirds namely, baya (*P. philippinus*), blackthroated weaverbird (*P.benghalensis*) and the streaked weaverbirds roosting in sugarcane fields from October to March and in a cat-tail (*Typha angustata*) and Marri (*Arundo donax*) stand for rest of the year. These birds roosted communally with common myna (*A. tristis*), bank myna (*A. ginginianus*), redvented bulbul (*Pycnonotus cafer*), Yellow wagtail

(*Motacilla flava*), white wagtail (*M. alba*), house sparrow (*Passer domesticus*), whitethroated munia (*L. malabarica*), spotted munia (*L. punctulata*) red munia (*E. amandava*), rose finch (*Carpodacus erythrinus* (Pallas)), redheaded bunting (*Embriza bruniceps* Brandt) and crowpheasant (*Centropus sinensis* (Stephens)).

Ali et al. (1979) observed that in paddy nurseries bayas fed on the exposed, germinated and ungerminated seeds and pulled out just germinated seedlings before they established. At the vegetative phase of the crop the birds cut the young leaf blades into strips for use in the construction of nests. After panicle emergence, bayas visited paddy crop in small flocks and by perching at the base of the panicle of each tiller fed on individual grains and rendered the panicle chaffy.

Ward (1965) found that quelea which damages rice in addition to sorghum, feed extensively on dry grass seeds throughout the dry season, mainly on *Echinochloa colonum* and *Panicum* spp. As the supply of these sources of food diminished there was a gradual change to larger seeds which included wild rice, *Oryza barthii*. In years when the change began early it coincided with the harvest of cereal crops causing severe damage to the crops. At the outbreak of rainy season the food supply for queleas was lost because the grass seeds on which they depended germinated. The birds, therefore, moved to areas of ripening grains. Though the diet was made up almost entirely of grass seeds, queleas also ate insects, especially when grass seeds became scarce. Insect eating appeared to be associated with reproduction. Queleas bred in

the wet season and during first week of dry season, a time when green grass was readily available for nest building and seeds and insects for food.

According to Grist and Lever (1969) munias are known to cause enormous damage to paddy crop in which they may be found in large flocks eating grain. These birds have been observed to move from field to field as the crop ripens and the authors opine that longer the period over which the harvest extends, the more broods of these birds can be expected (Grist and Lever, 1969).

Grist and Lever (1969) states that in West Pakistan, bird may destroy 20 per cent of the crop, even in the absence of conspicuous flock, so common in other countries. Such damage may extend from flowering time till harvest.

Dammermann (1929) while summing up the local knowledge concerning weavers and munias in Malaysia states that the breeding of these noxious birds takes place principally at the time of rice ripening, therefore more this period is extended, the greater the increase of these birds.

According to Stone and Mott (1973) the damage by redwinged blackbirds (*A. phoeniceus*) to agricultural crops is frequently confined to relatively few localized areas and 86-91 per cent of the fields surveyed by them suffered no damage at all.

During a study Pulliam and Mills (1977) observed that out of the eight species of finches they studied five species foraged on ground close to shrub cover and when flushed they invariably flew to cover. Another species, the chestnut-longspur (*Calcarius ornatus* (Townsend)) foraged in the areas of sparse grass and on ground. When flushed longspurs flew almost straight up and circled overhead calling noisily.

In an another study, Avery (1982) studied the nesting habits of Malaysian fantail warbler (*C. juncidis*) in rice fields of peninsular Malaysia. He observed that the nesting activity depended and varied according to the local rice growing practices in the peninsula where only two crops of rice were grown per year.

2.6 Avifaunal Succession :

According to Kendeigh (1974) succession is a gradual progressive increase or change in species composition. These changes result in part from the reactions and co-actions of organisms themselves and in part from such external forces as changing physiography or changing climate. In these conditions the habitat is usually affected as well as the community. But, there is frequently an inevitable change in communities with time, and that this change is often of a predictable nature (Price, 1975).

Further, during the process of terrestrial or aquatic succession, there will be a progressive increase in the species composition. This process is considered to involve a gradual and continuous replacement

of one kind of species group by another till the dominant community itself is replaced in the course of succession. Further, the process spreads over several years (Smith, 1965 and Odum, 1963).

In a study on succession associated with reclamation of tidal salt marsh in England, the breeding bird census revealed that each of the reclaimed section of marsh of different age was dominated by a different species. The three year old salt marsh and brakish pool succession was dominated by the meadow pipit, *Anthus partensis* (L.); the 12 year old soft mud pans, by the reed bunting, *Emberiza schoeniclus* (L.); the 19 year old hard mud pans by the yellow wagtail, *Motacilla flava* L.; and the 30 year old grassland by the skylark, *Alauda arvensis* L. (Glue, 1971).

Price (1975) stated that some species are actively involved in the dynamics of succession, because they cause changes that result in succession, and others are passive, since they merely respond to the change. In the latter case species arrive at different times and thus succession will result in part from differences in the rate of dispersal of colonizers. He considers the insects in rotting log are actively involved in succession as they radically change in conditions in the log. The insects on stored wheat act in a similar way by breaking down the grains and making them available to other species. According to him certain tiger beetles and pseudoscorpions are probably involved in passive succession as they merely respond to successional changes caused by other factors.

Shelford (1907) found that tiger beetle (*Cicindela* spp.) distribution was positively correlated with plant succession on sand dunes. In another study on an island off the North Carolina Mainland, Weygoldt (1969) found nine different species of pseudoscorpion species distributed from bayside to open sea side with respect to high tide line, presence of drift wood, grass, dunes, forest with pine and oak, leaf litter and availability of dead tree.

According to Smith (1965) natural fire, whether occurs in climax stage or in a seral stage, sets succession back to initial stages, and influences the species composition and shapes the character of the inhabiting community.

Similarly, grazing and browsing by wild animals arrests succession and even reverses it (Wiens, 1973). In African grasslands, grazing by large ungulates produces a sequence of vegetation alteration thereby influencing the associated avifaunal patterns (Bell, 1970).

Blake (1982) found that fire and logging in ponderosa pine habitat increased the species composition by increasing the foraging substrate availability in addition to seasonal influences. Thus habitat alterations through fire and logging brought about changes in the avifauna.

Similarly, Crawford and Titterington (1978) found that the successional pattern of bird species in upland coniferous forests are closely related to the plant succession following the habitat disturbance

due to silvicultural practices. Each seral stage was characterized by a group of associated bird species.

The bird succession in the Appalachian hardwood stands followed silvicultural practices. The changes in groups of birds could be predicted by the changes in configuration of overstory and understory vegetations (Crawford et al., 1981).

According to Titterton et al. (1979) commercial clearcutting in spruce-fir forests modify forest stands by changing vertical and horizontal structure of vegetation in the stand. Bird species respond to these changes in their habitat. Such silvicultural influences show groupings of bird species based on habitat features.

Succession and forest management of Loblolly-shortleaf pine forests influenced changes in the bird species composition, richness and density. Birds could be grouped in different successional stages (Meyers and Johnson, 1978).

Nilsson and Danell (1981) found that during the five year periods as the lake increased in age, the habitat complexity and the diversity and the evenness of water beetle fauna increased.

Johnston and Odum (1956) studied the bird populations along a successional gradient in the Piedmont of Georgia and found a bimodal pattern of species abundance. The number of species increased during

the early stages of old field succession, declined during early forest stage and then increased again in the mature forests.

According to Odum (1963), during succession an increase in potential niches resulted from increased biomass, stratification.

2.7 Avifaunal seasonality :

Seasonality in birds is most evident for physiological and behavioural event associated with reproduction, migration and moult. The annual cycle among birds and the underlying physiological regulatory mechanism emphasizes the variations in timing attributable to weather-related phenological factors (Weise, 1974).

Migration, among birds is an important phenomenon as these movements, are definite, regular, seasonal, and directional movements occurring usually between higher northern latitudes to lower southern latitudes (Thompson, 1964).

The 2100 odd species and subspecies of birds that comprise the avifauna of the Indian sub-continent and Ceylon, roughly about 350 forms are extra limited seasonal migrants, meaning that they breed outside our territory, mostly in the Palaearctic Region beyond the Himalayas in Central and Northern Asia and in eastern and northern Europe. The most abundant and regular winter migrants are the ducks, geese (Anatidae), wading or shorebirds (Charadriidae), especially of subfamilies charadrinae and scolopacinae; cranes (Gruidae) and the passerine families-

Hirundinidae (swallows), Muscicapidae, especially Muscicapinae (flycatchers), Sylvidae (warblers), Turdinae (thrushes and chats), Motacillidae (pipits and wagtails), Fringillidae (finches), and Emberizidae (buntings). In addition, many other families are represented among the migrants as well. Moreover, every gradation of migration is met with, from local movements of not more than a few kilometers or it may be a few hundred metres. Altitudinally in the Himalayas or Peninsular mountains, the enormous trans-Himalayan journeys involves several thousand kilometres each way (Ali and Ripley, 1968-1974).

Further Ali and Ripley (1968-1974) state that besides the large number of extralimital migrants, there are numerous other species whose palaearctic breeding grounds encroaches Indian boundaries on the Afghanistan, West Pakistan border and also into Gilgit, Ladakh, Garhwal, Nepal, Sikkim, Bhutan and northeastern Assam. Many of these species, spread over northern India, in winter and many over rest of the peninsula as well. In all respects these migrants behave as true migrants from beyond, arriving with them and spreading out over the country in autumn, chiefly between September and November and leaving again for their northern breeding grounds before Indian hot weather commences in March-April.

Seasonal changes in the species composition and abundance of birds were examined by Karr (1976). He found that seasonal variation in avian community structure decreased with increasing vegetation complexity. The impact of seasonality varied among subsets of avifauna. Insectivore species diversity and abundances generally varied more

seasonally then do frugivore diversity and abundances in structurally mature habitats. Further, he found that within shrub and forest habitats, the degree of seasonal variation in avian community composition changed with stratum. Karr's (1976) work supports the earlier findings that the community diversity and resource availability are correlated with seasonal irregularities in physical environment (especially rainfall in the tropics and temperature areas).

Fogden (1972) found that leaf production follows the onset of north-east monsoon. Insects and vegetation differed in their seasonality and distribution. The insect numbers were related to leaf production and hence were abundant during and after northeast monsoon. The population fluctuation of birds varied accordingly.

The seabird fauna of Peru showed a marked seasonality from October to March (Duffy, 1981).

Anderson et al. (1983) suggest that many important factors determining the occurrence and abundance of avian species probably acts outside the breeding season. The birds visiting lower Colorado river included several common, resident insectivorous and a number of other insectivores visited the study area in summer, some for several months. In addition, there were several winter visitors, including insectivores and granivores.

In New Guinea, Bell (1982) found only 19 out of 196 regularly observed species of birds in a rain forest in New Guinea showed significant

periodical changes in abundance. Two rails and two pittas decreased in dry, season probably because hard ground hindered their feeding. A wren-warbler and a rail responded to manmade changes in the habitat. Six species of lorikeets, and two species of fruit doves and one pigeon fluctuated in abundance in relation to flowering and fruiting of trees. Three species of insectivores, probably from Australia, visited in the Austral winter. Even the breeding seasonality varied among different groups of birds.

Nix (1976) in Australia found that breeding of different groups of birds and their sequence of nesting was correlated to the local periods of optimal plant growth, rather than the seasonal influence.

Anderson (1972) found the avifaunal activity was more dependent on food supply, nesting material, cover sites and other factors contributed to changing avifaunal activity, rather than seasonal climate alone.

Active growth of vegetation in Indian grassland is triggered by the advent of seasonal or monsoon rains, and the biomass grows to a peak value in about September. Following the maturity of rainy season vegetation biomass declines. (Singh and Joshi 1979).

During a study of the breeding biology of birds at Ranganathittu bird sanctuary Sharatchandra (1979) found the nesting season of birds to be from June to October. Pond and night herons commenced their nesting in March and egrets from June onwards. The commencement of

of nesting activity of most of the bird species was related to monsoon cycle.

2.8 Breeding habits of birds in tropics :

Most parts of tropics are characterized by a great heterogeneity of breeding seasons. Further geographical variation in the period of reproduction tends to be far greater than in temperate zones (Immelmann, 1971).

In the tropics, according to Immelmann (1971) the majority of birds exploit seasonal flush of vegetation and insects during the wet period. Among the passerines, a regular sequence in the onset of breeding has been found in many areas. First to begin are aerial hunters that feed on the swarms of flying insects appearing immediately after the first showers of the wet season. They are followed by species foraging among the foliage of trees and subsequently, by those hunting mainly for insects that live on grasses annual herbs (locusts, bugs) and that do not become available until late in the wet period. Most granivorous birds, finally, prefer the end of wet season and the first part of the dry season where there is a minimum supply of half ripe seeds.

Lack (1968), and Ali and Ripley (1968-74) observed that the nesting of these species starts with the onset of monsoon when they generally utilise the seasonal flush of vegetation and abundance for breeding.

Most birds of tropical regions have a regular change between one long dry and one long wet season per year, on the other hand, they breed around the rainy season with only a few specialists laying eggs during the dry period.

Immelmann (1971) indicates that the various breeding patterns in different parts of the world are the result of specific environmental adaptations. Every species is apparently adjusted to breed at the time of the year at which it can raise its young most efficiently. Further, by far the most important ultimate factor for nearly all species of birds is the availability of an adequate food supply.

Nesting materials required by various species are available only at certain times of the year. Among the Australian honeyeaters (Meliphagidae), those species that need large amounts of spider webs for nest construction begin breeding later in the rainy season than those that use other nesting materials this is correlated with the abundance of cobwebs during the course of wet period (Immelmann, 1963). This situation, which induces the seasonal nesting cycle among the above species seems to have been disrupted.

Avery (1978) while studying the diet and breeding habits of sharp tailed munias (*L. striata*) observed that at Bumbong Lima, Malaysia, the 6-month rice seasons were regular, well defined and provided abundant rice as well as protein source in the form of green filamentous algae, *Spirogyra* sp. He opines that these munias at Bumbong Lima have become

attuned to this situation so that their breeding activities are in concert with the availability of requisite environmental factors - rice and algae.

Avery (1982), who studied the breeding habits of streaked fantail warblers in the rice fields of Malaysia, found that the nesting activity of the species was synchronous with the availability of standing crop of rice and rice growing regime. Within each season the fantail warblers had extended breeding season because rice growing was asynchronous among the plots in the study areas. Further, the presence of nesting cover was determined by irrigation schedule (Avery, 1982).

2.9 Dependence of birds on vegetation :

Animals require shelter or cover as a protection against unfavourable weather conditions and enemies. According to Kendeigh (1974), vegetation is an important source of shelter for animals. Since, some animals which cannot tolerate too much solar insolation, seek shade. By staying under cover, prey animals may escape notice of passing predators or if detected, may more easily avoid capture. Dense vegetation throny thickets, burrows, and other situations impenetrable to predators are sometimes called as escape cover. Similarly vegetation can act as nesting cover, and roosting cover depending on the particular purpose which the cover serves (Kendeigh, 1974).

MacArthur and MacArthur (1961) found that bird species diversity was highly correlated with foliage height diversities. Similar views on the existence of a high correlation between vegetation of habitat

complexity has been held by several workers (James, 1971; Anderson and Shugart, 1974; Whitemore, 1977).

A study of the bird communities of the lowr Colorado River valley by Anderson et al. (1983) revealed that avian density and diversity was closely related to variation in the vegetation. Avian community attributes outside the breeding season were more highly correlated with the vegetation parameters than were those for communities during the breeding season. Vegetation density and diversity were both important predictors of avain community measures.

In American grasslands Cody (1968) observed that high species diversity was related with vertical grass height diversity. Initially, the habitat selection by bird species occurred horizontally and later when the grass grew the habitat seperation among species tended to be vertical. Cody (1968) considers that birds can search and pursue in different ways in short grass and can work at different heights in tall vegetation.

Similarly Wiens (1973) found that structural features of grasslands potentially important to birds was the height of emergent vegetation. Both the horizontal and vertical pattern of vegetation increased the heterogeniety which in turn contributed towards increasing bird species diversity.

In a study Davis (1957) observed that three species of towhee's foraging was highly influenced by the availability of cover. The spotted

towhee (*Pipilo erythrophthalmus maculatus* L.) foraged below the cover; Brown towhees (*P. fuscus mesoleuceus* Swainson) in open near cover and Abert's towhee (*P. aberti* Baird) foraged at intermediate distance from cover.

Pulliam and Mills (1977) studied the space utilization by eight species of North American sparrows in south eastern Arizona. These sparrows either foraged in different microhabitats or in the same habitat at different distances from tree or shrub cover. This resulted in certain species concentrating their activities in concentric rings about tree or shrub cover. The behaviour of each species appeared to enhance predator avoidance (hawks and falcons) and these behaviours changed in a regular pattern with distance to cover both within and between species. Species foraging close to cover are social and tend to be conspicuous both in behaviour and morphology. Two different strategies adapt species to avoid predators at great distances to cover. In dense grassland with increasing distance to shrub or tree cover, species in the genus *Ammodramus* are increasingly solitary and cryptic. In sparse grassland, chestnut-colored longspurs are social and cryptic on the ground but conspicuous in flight.

In a winter population of house sparrows, Barnard (1980) found that the birds foraged differentially in two distinct types of habitats: cattle sheds and open fields. The risk of predation was apparently higher in fields where birds scanned more frequently than in cattle sheds. The scanning was positively influenced by distance from cover.

2.10 Birds and predators :

The birds of prey mainly the falcons and hawks rely on surprise attacks to capture birds (e.g. sparrow hawks, *Accipiter niscus* (L.) on sparrows; redheaded merlins, *Falco chicquera* Daudin on house sparrows) and in most cases the avian prey are taken on the ground or in flight (Morse, 1973; Rudebeck, 1951; Subramanya, 1985; Bent, 1938).

Metcalf (1984a) indicated that birds prefer to forage in situations where they have an unimpaired view of their surroundings. In this study on shorebirds he studied the effects of reduced visibility caused by boulders adjacent to the foraging birds. A reduction in visibility caused an increase in the level of vigilance indicating an increase in vulnerability despite the greater degree of camouflage. This increase was due to individuals being less able to see both the approaching predators and also their own neighbours.

In another study Metcalf (1984b) observed that the vigilance among the shorebirds was 'shared'. This sharing was dependent on the number of other flock members the foraging birds could see. Time spent on scanning by an individual decreased as the number of other flock members the foraging birds could see. Time spent on scanning by an individual decreased as the number of neighbours it can see increased. Observation supporting the prevalence of shared vigilance have been made by Pulliam (1973); Diamond and Lazarus (1974) and Treisman (1982).

On the other hand nests of birds are commonly predated by mammals and snakes (Dahlsten and Copper, 1979). Though predation is a common cause for the loss of eggs and nestlings of birds hardly any predator would be caught in the act. According to Dahlsten and Copper (1979) snakes apparently remove the contents of the nest but do not disrupt the nest structure. On the other hand, mammal predation was easier to recognize as parts of the nestlings or adults present and the nests are disrupted.

2.11 Plant type and Bird damage :

Certain plant characters have been found to be associated with reduced susceptibility of crop varieties to bird damage. Doggett (1957) found that sorghum varieties with bent earheads ('goose-neck' type) escaped damage by *Quelea* in Africa. In such plants, the grain was taken only from the uppermost part of the panicle, which could be reached when the bird was perched upright on the head. As a result, goose-necked varieties escaped damage to the tune of upto 50 per cent.

In case of maize, Weatherhead and Tinker (1983) observed that in varieties of maize with cobs borne at lower level on the plant and palced in a horizontal position, being more vulnerable to attack by red-winged blackbirds. Similar observation was made by Bhatnagar et al. (1982) in maize attacked by crows and parakeets. Raju and Shivanarayan (1980) noticed a reduced preference of rice varieties by bayas and munias. The less preferred rice varieties had erect flagleaf.

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MATERIAL AND METHODS

III. MATERIALS AND METHODS

3.1 Study Areas :

Three study areas were chosen for the study of birds in paddy fields. The Hebbal area (HBL) (1 in Fig.1; Plate 1) served as the main study site, while the Nagavara area (NGR)(2 in Fig.1; Plate 2) and Kodigehalli area (KGH) (3 in Fig. 1; Plate 3) were chosen for comparison and gathering additional data. Each of the study sites had approximately an area of 8 ha and had been further subdivided into smaller plots. At HBL observations were made from July 1982 to early August 1984. while at NGR and KGH it was from April 1983 to April 1984.

The three study areas differed with each other with respect to the habitat features and physiogeographic positioning. The HBL and NGR areas were adjoining the Hebbal and Nagavara tanks respectively (Fig. 1), and were the sources for irrigation. Both these tanks received their impoundation of water during monsoon. During the summer of 1982 Hebbal Tank went dry except for few shallow patches of water to which a large number of water birds congregated. A vast marshy area was situated marshy tract nearby. The NGR area also had an ha marsh less than two acres closeby. At HBL, close to the farthest end of Marsh, an acre of dense stand of Bull rush reeds (*Typha* sp.) was present.

All the study areas were conspicuous low-lying areas surrounded by dry land cultivations. The NGR area was located amidst an expanse of paddy fields, while HBL and KGH areas were bordered on one side

DC = Dryland cultivations
 RC = Rice cultivations
 MDF = Military Dairy Farm
 UAS = Univ. Agric. Sciences
 T = Dense stand of *Typha* reeds

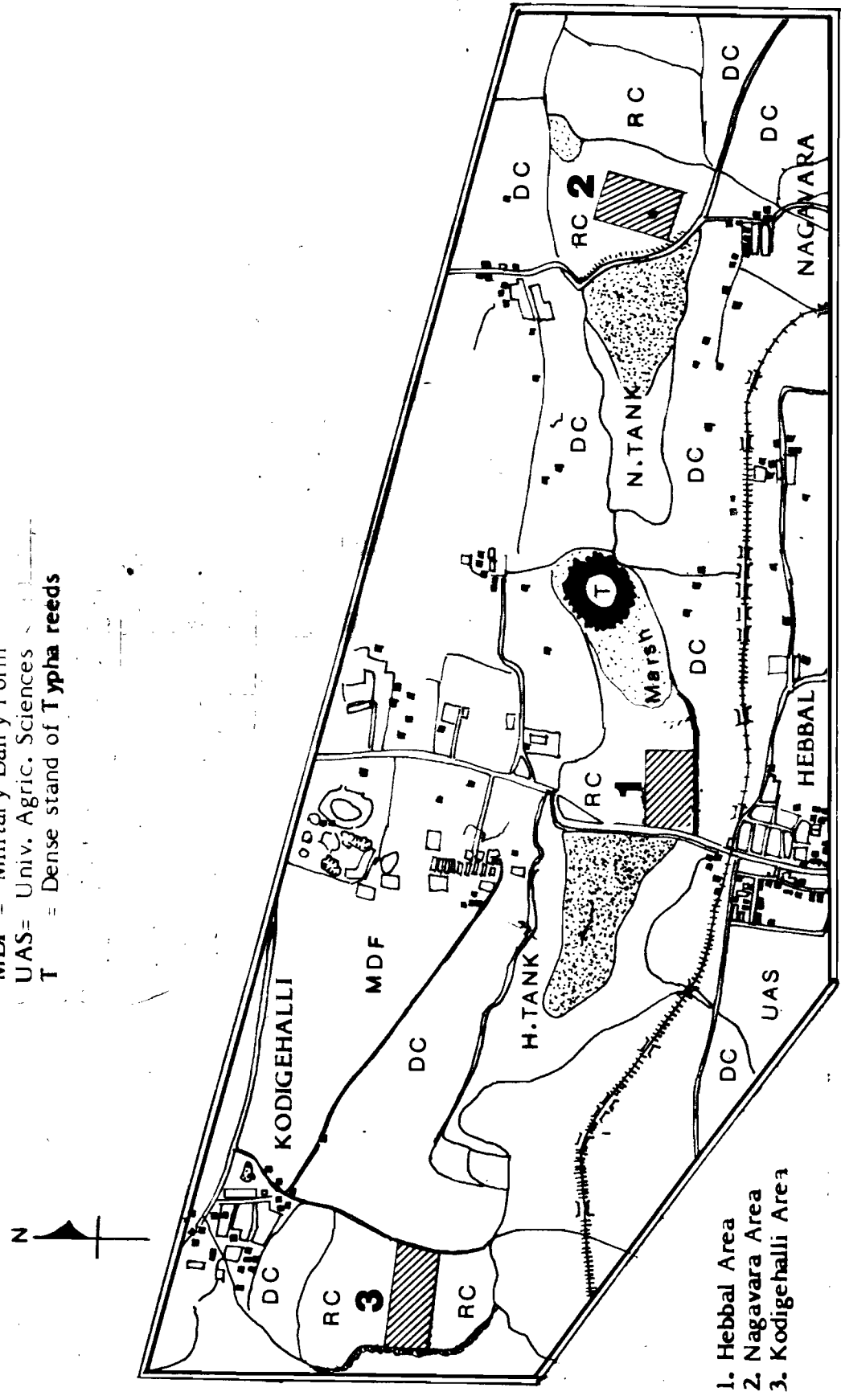


Fig. 1 Details of the study areas



Plate 1 : A view of Hebbal Study Area



Plate 2 : A view of Nagavara Study Area



Plate 3 : A view of Kodigehalli Study Area



Plate 4 : A view of the dense tree line at Hebbal Study Area

with dryland cultivations where mainly vegetables and ragi (finger millet, *Eleusine coracana* Gaertn.) were grown. Both HBL and KGH were close to urbanized residential localities, while NGR was part of a rural set up.

3.2 Vegetation Analysis :

Each of these areas had different surrounding vegetation (shrubs and trees). All the monocot and dicot plants above a metre height were recorded and were grouped into shrubs and trees. Coconut and arecanut palms were included under trees. The tree heights were visually estimated to the nearest metre (MacAurthur and MacAurthur, 1961). Hedgerows, when present were recorded and measured in length.

The vegetation diversity for each of the study area was estimated by using Shanon-Weaver diversity index (Pielou, 1976). At HBL and NGR areas, a twin electric lines passed overhead. Hebbal area was fenced all around with barbed wire secured to stone pillars erected at every 5 M.

In addition to paddy, sugarcane (*Saccharum officinarum* L.) was grown at HBL area from July 1982 to November 1983, in an area of 0.06 ha. Sunflower (*Helianthus annuus* L.) was grown during kharif of 1982 and 1983 over an area of 0.12 ha. During the summer of 1983 and 1984, soyabean was grown covering an area of 1.12 ha. Nearly half of the soyabean was under uneven stand during 1983 and had quite a few open patches and in such open plots *Paspalidium germinatum* (Forsk.) staff, grew abundantly and produced earheads that matured during April.

All the three areas had well laid out bunds and irrigation canals.

Each study area was divided into small plots for cultivating paddy.

3.3 Climate :

Based on the fluctuations in temperature, rainfall and relative humidity, three main seasons can be observed in Bangalore (Fig. 2). The hot season begins by the end of January or middle of February and extends till the third week of May. The rainy season starts with pre-monsoon showers which begin during the last week of May.

South-west monsoon becomes active by the end of first week of June. From September onwards the north-east monsoon brings rains till the end of October or early November. Winds are generally strong during south-west monsoon. The rainfall in Bangalore, usually shows two peaks; one during May - June and the other during September - October. The cool season is from November till January or early February.

The details of fluctuations in temperatures, rainfall, relative humidity and evaporation are presented in Fig. 2.

3.4 Cultivation of paddy during the study period :

Paddy was grown in the study areas during two seasons of a year. The main season, began with commencement of monsoon (June-July) and extended upto November-December. The second season began by December-January and went on till April-May, June. The extended season was mainly due to staggered planting and harvesting of paddy

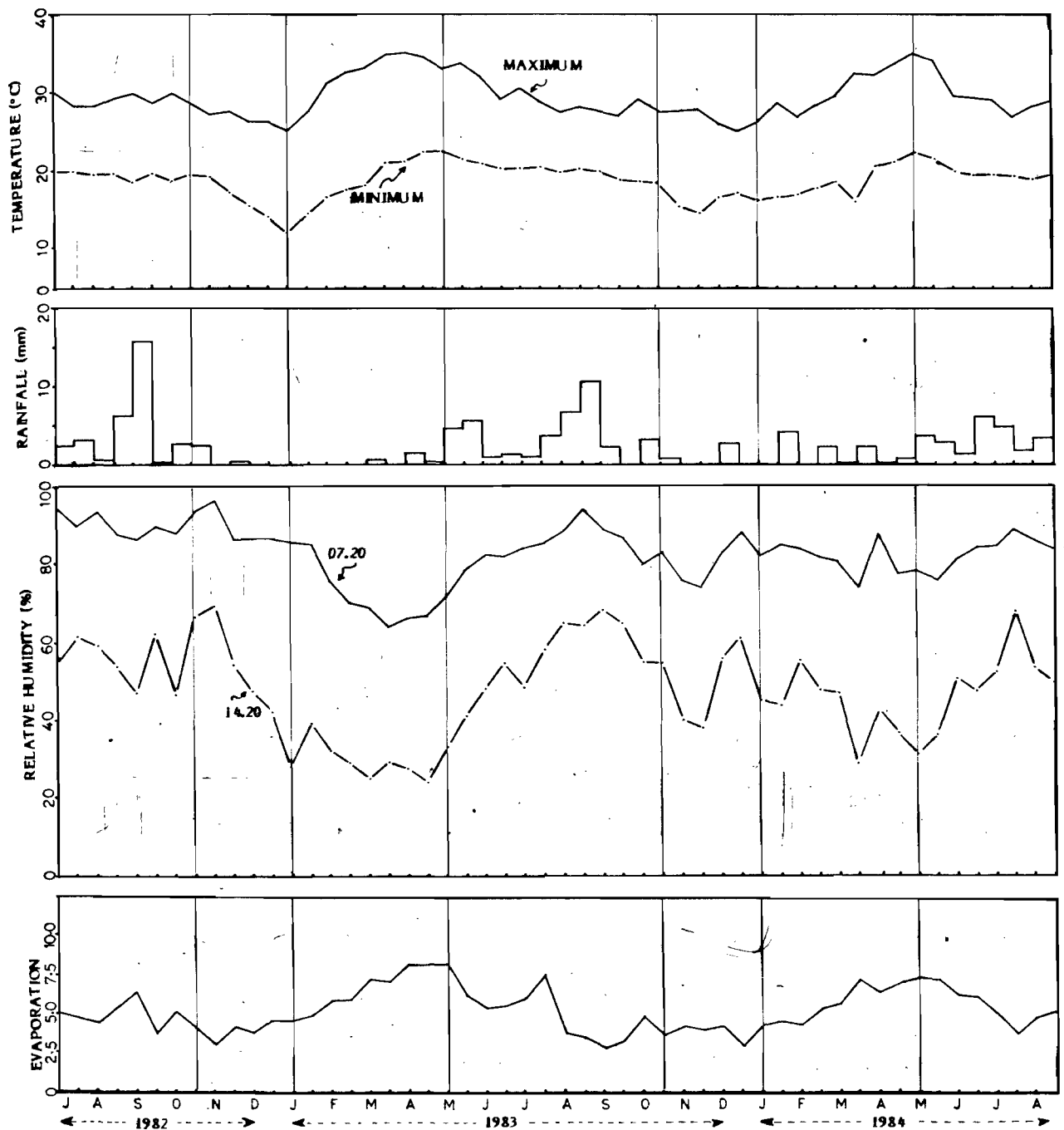


FIG. 2: DETAILS OF WEATHER DURING THE STUDY PERIOD

crop within each of the study area. As a result, asynchrony existed from one plot to another with respect to plot conditions and crop stand.

Paddy cultivation was usually taken up with three preparatory cultivations namely, plowing, puddling and levelling. After the harvest, the plots were usually left fallow in a dry or inundated conditions before the next season's operations began. These plots when left uncultivated and inundated, were usually got covered with *Cyperus* sp. among the sprouting of stubbles. In addition, other weeds, such as *Oxalis corniculatus*, *Leptochloa* sp. *Jussia repense*, *Echinochloa* sp. were common. In puddled plots that were left inundated and uncultivated for more than a month, encouraged the growth of filamentous algae, *Spirogyra* sp. in small patches.

In all the three study areas, crabs (*Oziotelphusa* sp.) were common. They burrow inside inundated plots, along the edges of plots close to the bunds or burrow into the bunds itself. On several occasions the crabs burrowed across the bund into the adjoining plot or into irrigation nals. As a result, considerable loss of irrigation water through seepage occurred, at times, draining the entire plot. Some vertebrates found in the study areas were the common mongoose (*Herpestes* sp.), bandicoots (*Bandicoota benghalensis* (Gray and Hardwicke)), the mice, *Mus musculus* (L.) snakes the Chekkered keelback (*Tropidonotus psicator*) and cobras (*Naja naja* (L.)) etc.

3.5 Bird Censusing and other observations :

The main method of data gathering was by censusing birds in each of the study area. Bird censusing was carried out by spot map

method according to the International Bird Census Committee (1970) and based on previous studies (e.g. Cody, 1968; Conner and Dickson, 1980). During the census, the position of individual species sighted were marked on a small scale map of the study site. In addition to marking the positions of different individuals present in each of the paddy plots in the study area, the field condition of each plot at the time of the census was recorded on the map itself. The field conditions classified for the purpose is given in Appendix III

Census was carried out within two hours after the sunrise, following the methods of Dickson (1979) and Cody (1968) by walking along a fixed route within the study site. As the route was traversed from the starting point, several stops were made at pre-fixed points to mark the positions of birds and the condition of the plots.

Spot mapping was also supplemented by flushing of birds from standing crop. This method was adopted to count the individuals of nesting species and those which had the habit of lurking inside the cover of standing crop or feeding among the bases of paddy crop. Two additional transects parallel to the census paths were established for flushing. While walking on these additional transects on the bund close to edge of the plots with standing crop of paddy, few clumps at the edge of the plots were kicked frequently and the noise thus produced flushed the birds lurking in the vegetation. Birds like weaverbirds and munias were flushed from their resting sites on to the tops of adjoining trees (at HBL and KGH) overhanging electric wires (as at NGR) for counting

them. Use of such additional method to improve the census counts was taken up according to the suggestions made by Karr (1981) on the need for additional methods of surveying birds in tropics.

Birds that were seen in vegetation inside or adjoining the study areas, but not utilising rice fields by way of feeding, nesting, roosting or those flying overhead were not counted. However, raptors (Accipitridae and Falconidae), swallows (Hirundinidae) and swifts (Apodidae) were counted as they normally feed or hunt on the wing (Kricher, 1972; Ali and Ripley, 1968-74) and would therefore be utilizing the study areas from air.

About four to eight censuses were carried out per month (Dickson, 1979), and census was not conducted on rainy and heavy misty mornings. During rest of the census day the study areas were visited to collect details on their food habits, nesting habits and general ecological observations. During the first fortnight of September 1982 due to frequent rains census was not carried out.

The species composition was worked out from the observations recorded during the censusing of each area. The census data was used to determine the status of the bird which was determined by two means :

- (a) commonness status : whether the bird is a regular or irregular visitor,
- (b) residency status : as to, if the the species is nesting within paddy fields, or a resident in southern India but not using paddy fields

for breeding, or a migrant, either an altitudinal migrant from north or from palaearctic region. The residency status of each species was fixed by using the information available from the Hand book of birds of India and Pakistan (Ali & Repley, 1968-1972) and based on the active nests and young juveniles (for rails) seen in study areas.

Pattern of utilization of paddy field by birds was worked out by studying whether the birds frequented paddy fields for only feeding, or nesting, roosting or using the standing crop as a cover (Shelter) to take refuge from aerial predators. The nature of guild (Root, 1964) membership was worked out based on the food and feeding habits of the species observed in the study areas and also based on the information provided by Mason and Lefroy (1912) and Ali and Ripley (1968-1974). The type of flocking habit i.e. solitary or gregarious and types of micro-habitat (Appendix III) preferences among the birds was also recorded during the observation period.

The data collected through censusing were converted into fortnightly averages and these values were used to understand the seasonal abundance and fluctuation of the species recorded in each of the study areas. Within the study areas the activity pattern of birds were observed.

Response of birds to cultivation of paddy crop was studied by observing their reaction to : (a) different cultivation practices and harvesting of mature crop; (b) different field conditions and crops at different growth stages. Details of the species and their numbers responding to cultivation practices recorded, from a few minutes prior to the

commencement to the cessation of the operation. Any prey item taken during this period was also recorded. To know the differences in the prey abundance and availability, in plots before and during their cultivation, 10 samples were collected by plough exposure method (Robert and Smith, 1972). The number of soil invertebrates exposed per metre length of the freshly opened furrow, by moving plough was counted. Prior to commencement of ploughing, counts were made in the same plot in an area of 45 x 100 cm and the same were used for comparison. A mean of ten samples was used for the purpose.

Similarly, the response of birds to harvesting of paddy was also recorded from commencement to cessation of the operation.

Details of food eaten by birds in rice fields was recorded following an arbitrary rule : One bird, one food = one record (Newton, 1967). Whenever possible, the prey items were identified by using binoculars from a close range. In addition to these, an emetic, Antimony potassium tartarate (Prys-Jones et al., 1974) was used to obtain the food from the nestlings of streaked fantail warblers. The emetic was administered by means of a 1 ml syringe and a 3 cm length of thin flexible plastic tubing with an external diameter of 2 mm. With the bird held in an upright position, the tube was inserted into the mouth and gently pushed down the oesophagus. The emetic was then administered slowly. The dose used was 0.15 ml for the nestlings of 10 days age and above were used for obtaining the stomach samples. The samples thus obtained was preserved in 4 per cent formalin for further analysis. This method

was used to supplement the direct field observational data. The details of food habits thus collected was later expressed as the per cent frequencies of food items taken.

In case of vertebrate feeders the feeding bird was flushed from its feeding site and the discarded remains like feathers, fur, body segments, skeletal parts etc., were used for identifying the prey groups. No effort was made to capture the bird so obtain its stomach contents. Feeding habits and behaviour of bird species was gathered by direct field observations.

Once in fortnight during 1983-84, all the three study areas were searched, closely to gather the empty carapaces of crabs discarded by birds after feeding. The carapaces were collected from bunds, base of feeding posts and ^{other} feeding sites. These fortnightly collections were pooled to express as monthly totals.

Nesting activity of species breeding within the study area and outside was closely monitored. The details of nesting activity of birds was recorded on a modified version of the British Trust for Ornithology (BTO) Nest Record Card (Hochoer, 1972) and the modified card is presented in Appendix-I. Most of the nests were located by observing birds with either food material or nest material in their beaks and tracking them to their nests.

Once a nest was sighted, a nest record card was opened and all the observations made during subsequent visits were recorded in it, date and timewise details on egg laying, incubation period, nestling period along with the outcome of the nest with regard to successful completion or failure of the nest was recorded. If the nesting attempt was to fail, the reasons for such a failure was recorded. In addition, the height of nest from the ground level and heights of plants bearing the nest was also recorded. From the data thus collected, partial life tables (Dahlsten and Copper, 1977) were constructed for species wherein observations on more than 10 nests were available for nests found within the study areas.

For those found outside the study areas and in different habitats (when the birds frequenting rice fields happen to nest in totally different habitat) only the date of nest sighting, stage of nesting and success of nesting was recorded. Even sightings of young juveniles with their parents was considered as an indication of breeding within the study area.

While recording observations on birds frequenting different field type or the crop stage, attention was paid to record the species involved, their feeding pattern and mode of use of the field type or crop stage.

Whenever a bird was seen feeding, its feeding manoeuvres were recorded. Attention was paid to note down the place or type of perch from which the bird made the manoeuvre, if the bird was perched or the flight pattern and mode of attack if the bird was airborne; the substrate towards which the manoeuvre was directed. The substrates were categorised into 31 microhabitat types (Appendix IIIB) available within paddy fields. After capturing the prey, details on birds subsequent activities as to flight to feeding perch, if any or preparation of the prey before devouring the same were recorded.

The activity pattern of bird pests was monitored by monitoring their movements within and outside the study areas. Their arrival to and departure from the study areas and their concentrations in large numbers outside the study areas if observed was recorded. The roost site of pest species frequenting each of the study area was located by following flightline of birds leaving the study area during evening (Caccamise and Lylon, 1983).

Details on the occurrence of flock size of different species in each area and the tendency of each species to mix with others were noted. Food habits of these birds in the surrounding areas and on foods other than paddy was recorded.

Based on preliminary observations, a minor millet *Echinochloa colanum* was grown in a 0.041 ha area at Hebbal study area and the response of the bird to the mature crop was studied till the crop was harvested.

To study the preference of paddy varieties, a field trial with seven varieties was laid out using Randomized Block Design. The varieties were Pragathi, IR-36, IR-42, IR-48, C7-1351, Jenugudu and Doddabyra. Of these, C7-1351, Jenugudu and Doddabyra were local varieties while, the rest were dwarf hybrid varieties. In order to understand the varietal preference each variety was scored for six characters namely, plant height, angle of the flag leaf from the horizontal ($0^\circ - 90^\circ$), extent of the projection of flag leaf above the earhead, earhead type (drooping; drooping to semi-erect; semi-erect and erect), spread of the plant at earhead level. The number tillers of the plant with damaged earheads and expressed as per cent damage. Data collected on ten plants selected at random for each variety was used for analysis. The data was further subjected to hierarchical cluster analysis (Sokal and Sneath, 1963), to group varieties based on birds' preference. The samples of each variety was pooled later to study the association between different plant characters chosen and the extent of damage due to birds.

3.6 Data Analysis :

Comparison between the study areas and species frequenting different habitat types were made using Sorensen's coefficient of similarity (Southwood, 1966).

$$C = 2j/(a + b)$$

Where, j is the number of species common to the two samples and a and b respectively the total number of species in each sample.

Equality between samples with unequal number of observations was tested by using Mann-Whitney 'U' test (Siegel, 1976).

Bird diversity in each of the study areas was calculated by using modified Simpson index (Rottenberry, 1978). Thus,

$$\text{Diversity} = 1/\sum P_i^2$$

where, P_i is the relative abundance of the i th species in the sample.

The richness component is simply the number of species in the sample. Evenness (the distribution of relative abundance among the species unused) was calculated using a ratio proposed by Hill (1973) (Rottenberry, 1978).

$$\text{Evenness} = \text{Diversity} / \exp(-\sum P_i \log P_i)$$

Preference for different rice varieties by birds was analysed by subjecting the matrix containing the mean values of characters with which each variety was scored, to hierarchical cluster analysis (Sokal and Sneath, 1963) wherein the values obtained for each object (variety) scored against several characters were converted into distances (Sokal and Sneath, 1963). The two objects (varieties) which shared the highest similarity were joined first and subsequent objects were joined to this cluster on the basis of their relationship to the most distant member in the cluster (Sparling and Williams, 1978).

Further, the association among and between different plant characters, chosen and the extent of damage was obtained by determining correlation coefficients (Snedecor and Cochran, 1967).

* * *

RESULTS

Table 1. Details of the Study Areas

	Hebbal	Nagavara	Kodigehalli
1. Vegetation	Dense treeline, Bushes, Hedge Row	Bush Clump	Open treeline
2. Percentage of Border occupied by treeline	50.00	-	20.50
3. Percentage of Border occupied by Hedge Row	66.67	-	-
4. No. of tree species*	16	1	6
5. Total No. of trees	234	1	63
6. No. of Bush species*	2	1	-
7. Total No. of Bushes	46	4	-
8. No. of Hedge species	1	-	-
9. Vegetation species diversity**	2.2452	0.5004	1.5379

** = Species Diversity = $-\sum p_i \log p_i$ (Pielou, 1976)

* = No. of tree and bush species indicates species richness

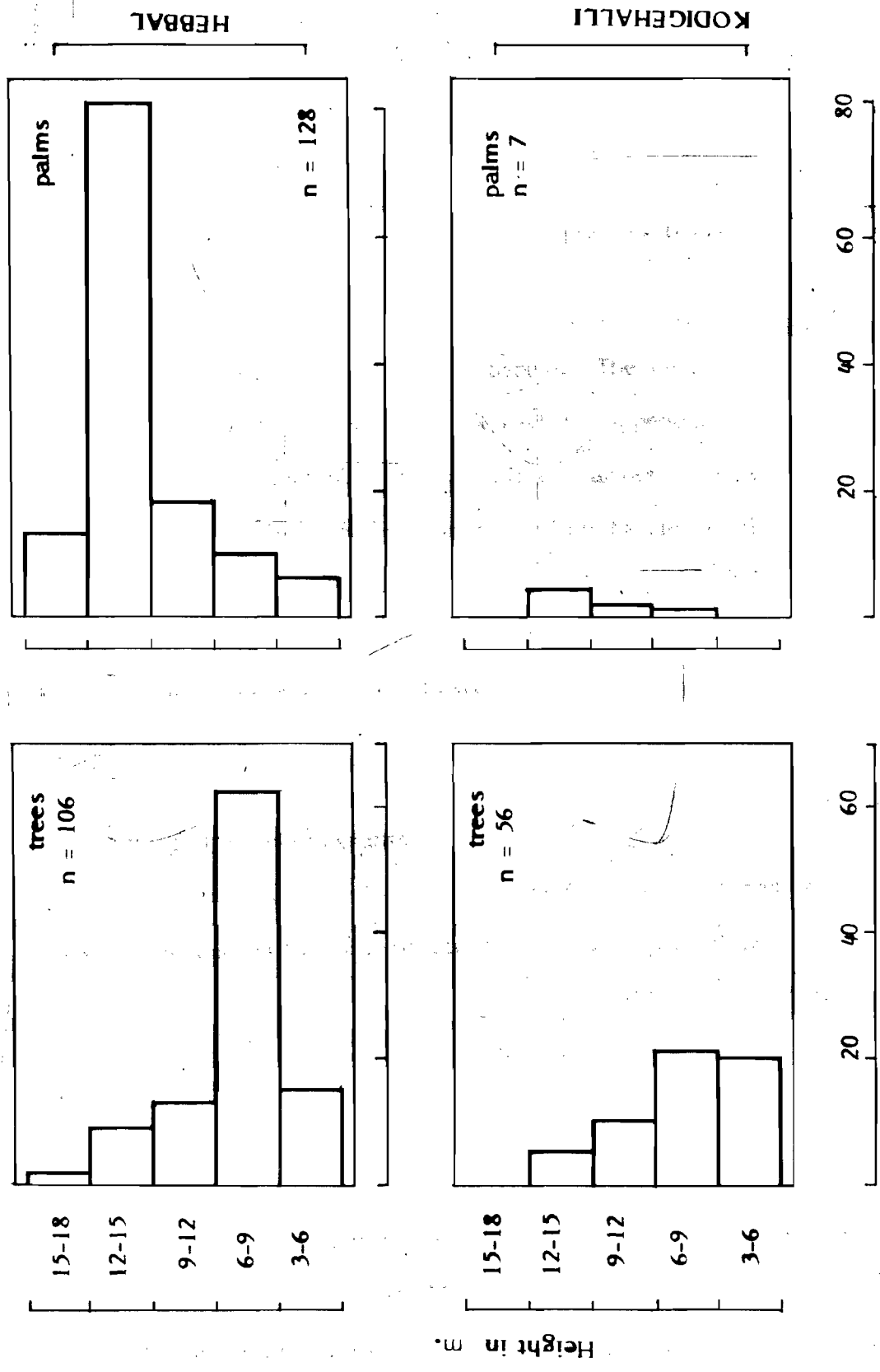


Fig. 3 - Height and groupwise break up of vegetation at Hebbal and Kodigehalli areas

The approximate distances of HBL, NGR and KGH areas from the bulrush roost site was 0.75, 1.50 and 2.00 kms, respectively. The finches, excluding house sparrows flew from and to this stand of bulrush, and the surrounding countryside, every morning and evening.

4.2 Bird species composition and their residency status :

A total of 81 species of birds belonging to 27 families under 11 orders were sighted during the study period. The details of the taxonomic position of each species is presented in Appendix IIIa. Of the 81 species, 28 were migrants including five transient species and the rest were resident. The transient species (Pale harrier, baird's crane, greyheaded lapwing, golden plover and rosy pastor) were sighted only once or twice. Even though blyth's and great reed warblers were seen once and twice, respectively, they were considered as migrant irregulars as they were common in the surrounding areas of HBL.

Among the non-migrants, four groups were recognized. They were, regular breeders, irregular breeders, regular ~~residents~~ and irregular ~~residents~~. Species membership under these groups varied greatly from one study area to another. The details of the residency status of birds recorded during the study is given in Appendix IIIa. The total number of species recorded at HBL, NGR and KGH are 74, 61 and 52, respectively (Table 2).

The number of regular resident species at HBL were 17, 20 at NGR, while at KGH it was 16. The irregular residents were 20, 14 and 11 at HBL, NGR and KGH, respectively.

Table 2. Residency status of birds in rice fields

Species Residency category	Study areas		
	Hebbal	Nagavara	Kodigehalli
1. No. of regular breeders	9	4	7
2. No. of irregular breeders	3	3	-
3. No. of regular residents	17	20	16
4. No. of irregular residents	20	14	11
5. No. of regular migrants	15	13	14
6. No. of irregular migrants	6	6	2
7. No. of transients	4	-	2

Similarly, the number of regular and irregular migrants among the study areas showed variation (15, 13 and 14 and 6, 6 and 2, respectively at HBL, NGR and KGH; Table-2).

At HBL area 9 regular breeders were recorded, while it was 4 species at NGR and 7 at KGH. The number of birds species recorded as irregular breeders were three each at HBL and NGR area.

Hebbal area had the highest number of transient species (4) and at KGH area two transient species were recorded. No transients were recorded at NGR.

4.3 Utilization of rice fields by birds :

Birds frequented rice fields for food or use the standing crop as shelter or cover, or as a site for nesting or to roost at night.

Among the 81 species recorded, 61.17 per cent of the species visited rice fields solely for feeding; 8.46 per cent for food and roosting 7.41 per cent each for food and cover, food and nesting and for food, cover and roosting. Only 2.47 per cent of the species used rice fields for food, nesting and cover. The number of bird species using rice fields for all the above purposes comprised 6.17 per cent (Fig. 4).

From the Appendix IIIa, it is quite evident that most of the herons and egrets, storks, all the birds of prey (the hawks falcons, kites and harriers), jacana, lapwings and other plovers, sandpipers, gulls, pigeons and doves, parakeet, plaintive cuckoo, spotted owl, swifts, kingfishers,

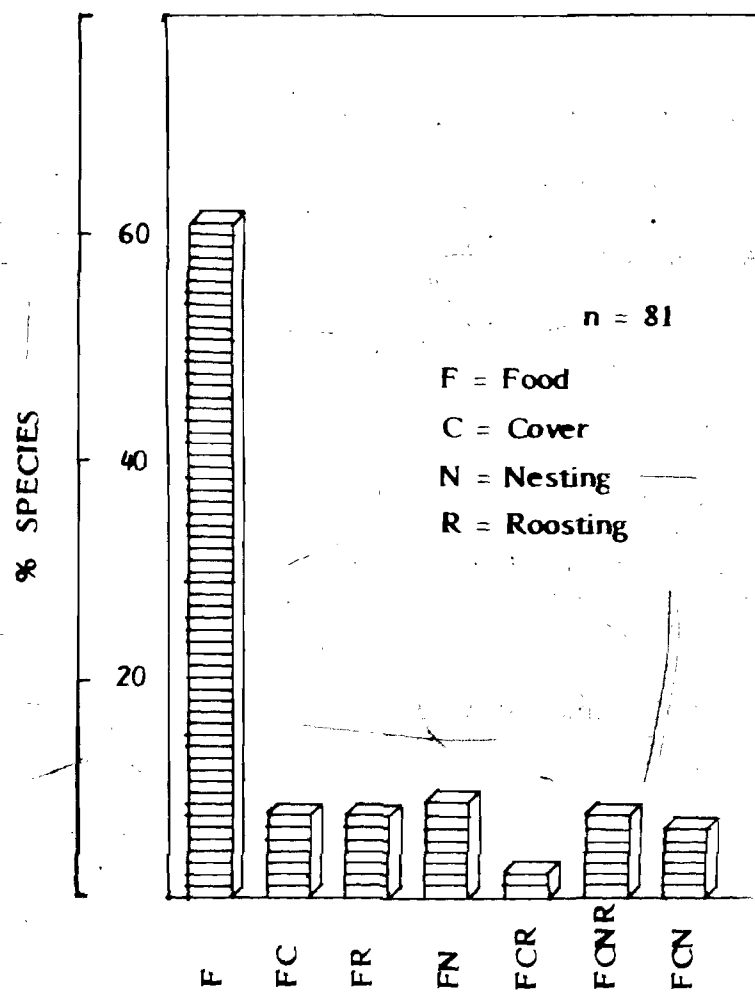


Fig. 4 Utilization of rice fields by birds

bee-eater roller, hoopoe, swallows, shrike, drongo, rosy pastor and mynas, crows, whiteheaded babbler, largepied wagtail sparrow, streaked baya and munias visited rice fields only for obtaining their food.

Larks, pipits, baya weaver and blackheaded munia used rice fields both for nesting and feeding.

Most of the rails, nipe (*Capella* sp.) painted snipe and paddyfield warbler and the bluethroat used rice stands for food, cover and roosting.

Among those that used rice fields for food, cover nesting and roosting, were bluebreasted banded rail, ruddy crane, whitebreasted waterhen, streaked fantail warbler and Indian wren warblers (Appendix IIIa).

4.4 Succession of birds in rice fields :

With the sequential changes in conditions of the rice fields due to different cultivation practices and growth of rice crop, a succession in bird life was evident. The successional pattern of birds based on their utilization of different field conditions is shown in (Fig. 5 & 6). The details of the species composition in different successional stages is given in Appendix IV.

The number of species associated with different successional field stages showed two distinct peaks during ploughed-puddled/levelled stages and again during grain filling/maturing stages (Appendix IV and Fig. 6). However there existed a low similarity coefficient of 0.1563 between these two peaks (Table 3).

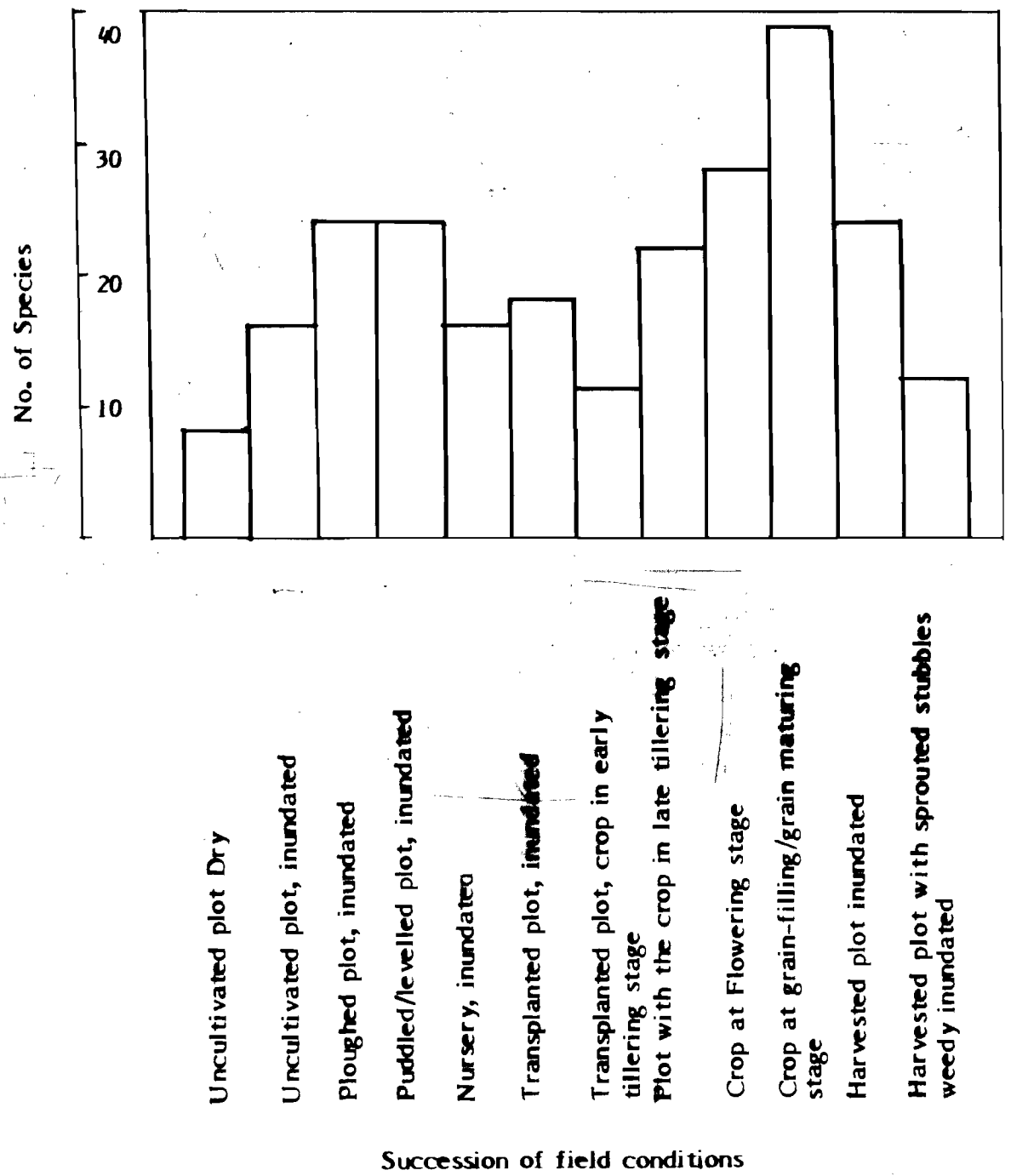


Fig. 6. Successional pattern of birds in rice fields

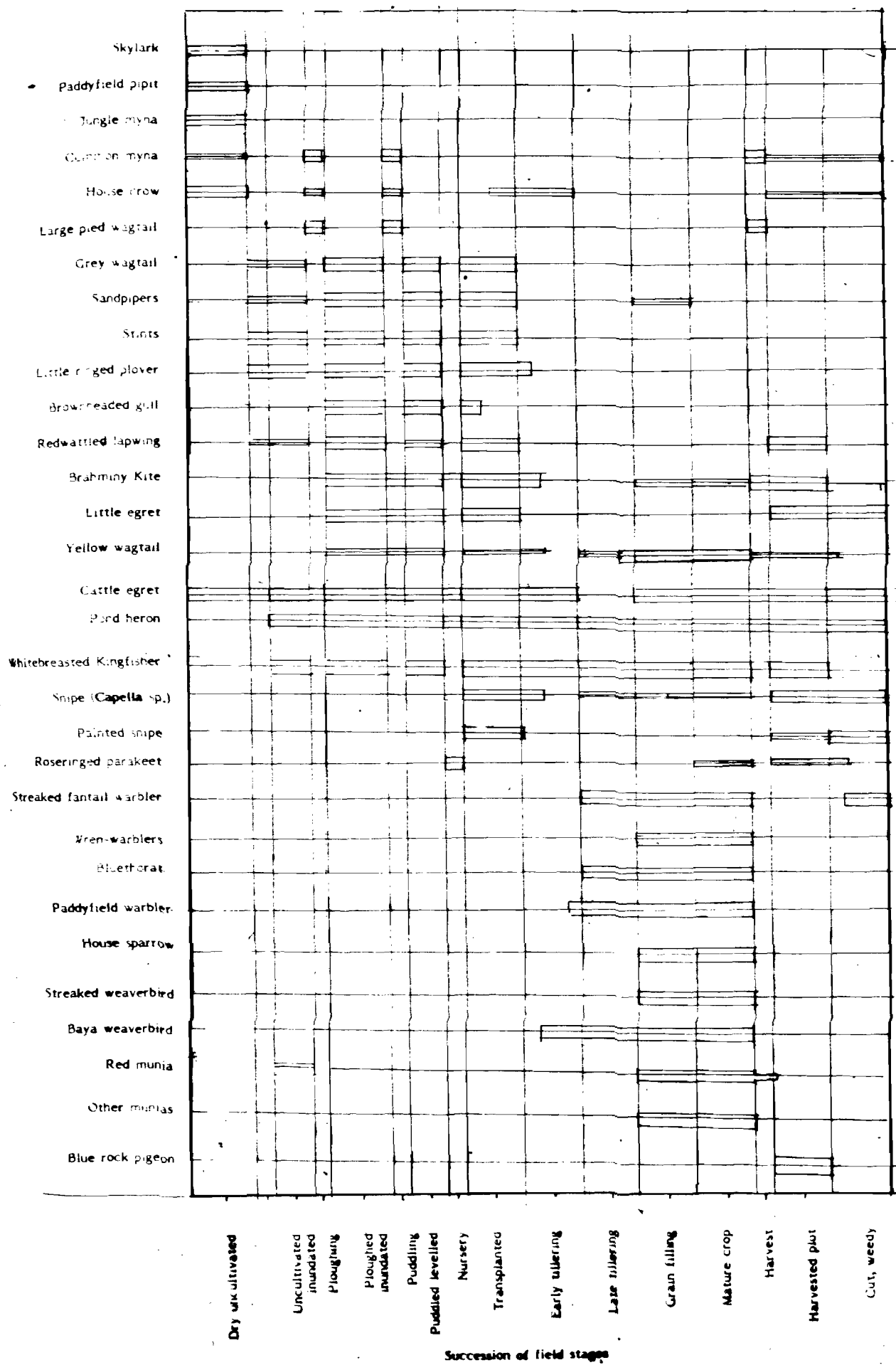


FIG. 5 : BIRD SUCCESSIONAL PATTERN IN RICE FIELDS

Table 3. Bird species similarity coefficients* among different successional stages in rice fields.

	Uncultivated, inundated	Ploughed, inundated	Puddled/levelled, inundated	Nursery, inundated	Transplanted, inundated	Early-tillering, inundated	Late-tillering, inundated	Grain filling/grain maturing	Harvested, inundated	Cut, stubble sprouted, inundated
1. Uncultivated, dry	0.0870	0.1250	0.1250	0.0833	0.0769	0.1053	0.1333	0.1111	0.1333	0.1000
2. Uncultivated, inundated	-	0.6154	0.6154	0.7742	0.7879	0.3077	0.1622	0.1861	0.5556	0.4444
3. Ploughed, inundated	-	-	0.9583	0.7000	0.7143	0.2857	0.2174	0.2308	0.3111	0.3333
4. Puddled/levelled, inundated	-	-	-	0.7500	0.6667	0.2857	0.1739	0.1923	0.6087	0.3333
5. Nursery, inundated	-	-	-	-	0.7647	0.3704	0.2105	0.2941	0.5789	0.3571
6. Transplanted, inundated	-	-	-	-	-	0.3448	0.2500	0.2174	0.6000	0.5000
7. Early tillering inundated	-	-	-	-	-	-	0.6061	0.4103	0.4242	0.8182
8. Late tillering, inundated	-	-	-	-	-	-	-	0.8400	0.2727	0.4849
9. Flowering	-	-	-	-	-	-	-	-	0.2400	0.2564
10. Grain filling/grain maturing	-	-	-	-	-	-	-	-	0.2581	0.1509
11. Harvested (cut), inundated	-	-	-	-	-	-	-	-	-	0.4849
12. Cut, sprouted, stubble, inundated	-	-	-	-	-	-	-	-	-	-

* Similarity coefficients vary from a low similarity value of less than 0.1000, to a maximum similarity coefficient value of 1.0000.

- Regions of the similarity matrix enclosed in **Bold Letters** indicate field conditions having highly similar bird fauna.

There was a gradual change in the species composition as the field conditions changed from dry cultivated condition to the harvested plot with sprouted stubbles and weeds (Appendix IV). The species number increased from dry uncultivated plot (9 spp.) to ploughed, puddled/levelled plots (24 spp.). By the time the transplanted crop reached tillering stage, the species number dropped to 11 and again their number showed a sharp increase with the grain filling/grain maturing stage, reaching a maximum of 39 species. The number of species visiting the last two stages i.e. harvest and harvested plots with sprouted stubbles, declined to 24 and 12 species, respectively (Fig.6).

The similarity coefficients of bird species among different successional field conditions presented in Table 3 shows three distinct sets of high faunal overlap stages (coefficients enclosed in boxes). It can be seen that field conditions 2, 3, 4, 5 and 6 (as in Appendix IV) prior to tillering stage showed a high similarity with respect to avifaunal similarity among these stages ($C > 0.45$) with highest similarity being observed between ploughed inundated and puddled/levelled inundated fields ($C=0.9583$).

Marked similarity was again observed between field conditions 7 and 8; 8, 9 and 10 stages which included successive crop stages from late tillering to the mature crop stage ready for harvest.

After the mature crop was harvested a similarity coefficient of over 0.45 was observed between field conditions 2 and 11; 11 and

4, 5, 6; 12 and 6, 7, 8 and 11 (Table - 3 and Appendix IV). Excluding the above successional field conditions the similarity coefficients between any two stages was extremely low (Table-3).

Dry uninundated and uncultivated plots were occupied by birds such as cattle egrets (Plate-5) pipits, larks and red wattled lapwings (Plate-6) for nesting during summer months as at KGH. Occasionally pond herons were seen foraging in dry stubble covered plots at KGH. Cattle egrets were also seen foraging in grass covered or stubble sprouted plots during January, February at HBL.

Where the dry plots were inundated the larks and pipits disappeared and were replaced by stints, sandpipers, stilts, little egrets, pond herons, (Plate 7). When these plots offered enough cover from the thick growth of weeds (*Cyperus* spp) and sprouted stubbles, painted and common snipes were seen using the plots.

Whenever these inundated plots were either ploughed, puddled and levelled, brahminy kites, (Plate - 8) crows, mynas, egrets and very few pond herons were attracted. The inundated plots after plowing, puddling and levelling in addition to pond herons and egrets, attracted birds like spotted sandpipers, blackwinged stilts (Plate-9), little stints, common snipes, pond herons and little egrets. During winter, brown-headed gulls frequented NGR, HBL areas whenever the plots were being puddled, to pick up crabs. All these species continued to feed in these plots till the transplanted crops reached late tillering stage when they were replaced by species e.g. warblers, which preferred to forage within



Plate 5 : Cattle Egret, an open field carnivore in rice fields



Plate 6 : Redwattled Lapwing, a regular open field forager in rice fields



Plate 7 : Pond Heron or Paddy Bird, a bird characteristic of rice fields



Plate 8 : Brahminy Kites attracted to a field under ploughing

the dense stand of rice plants. Species like the bluebreasted banded rail, ruddy crake, baillon's crake, whitebreasted waterhens, (Plate - 10) kora the water cock being ground foragers preferred to remain within the cover of the standing paddy plants. Whenever these species were sighted for example, on the bund separating two adjacent plots with standing rice crop, they immediately disappeared by skulking into the gaps between the nearest hills of rice. Fig.7.

Warblers like Indian Wren-Warbler, streaked fantail warblers, paddyfield warbler, blyth's and great reed warblers foraged inside standing paddy crop, gleaning insects from the leaf and plant surfaces. They were found only after the crop passed mid-tillering stage and continued to use the crop past mid tillering stage till harvest. Fig.7.

The spotted sandpiper, snipes (*Capella* sp) foraged at the edge of inundated plots with standing rice and the latter invariably sought refuge among the standing rice plants. The painted snipe disappeared into the gap between two paddy hills, while sandpiper and the snipe (*Capella* sp) took to their wings when approached closer.

Pond herons foraged at the edge of rice plot when the whole field was covered with standing crop. Yellow wagtails foraged among the tillers, on the ground whenever water was shallow or plots were wet.

As the crop pushed out the earheads and the grains began to fill, the granivores like, parakeets, baya weaverbirds, munias visited

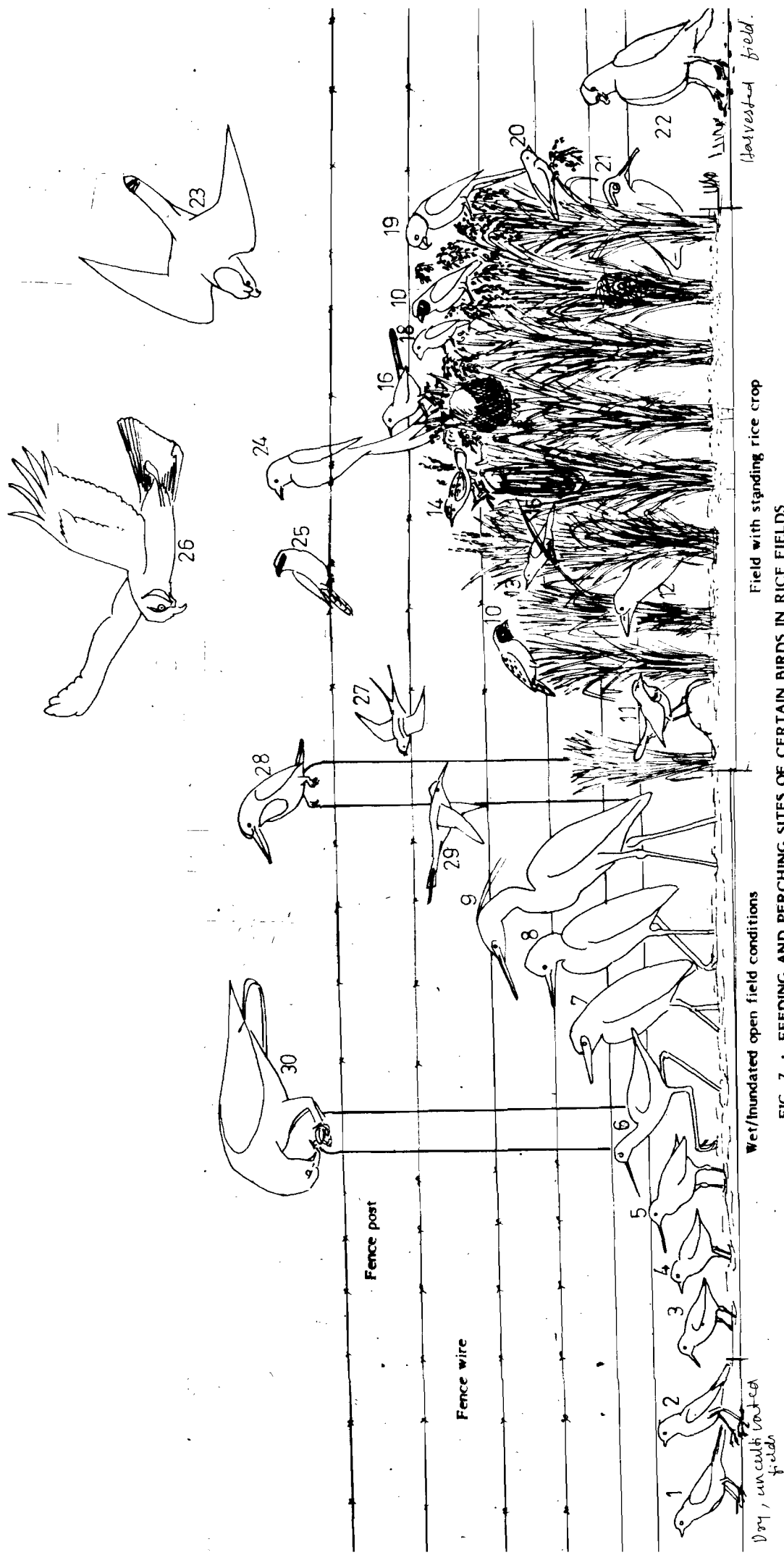


FIG. 7 : FEEDING AND PERCHING SITES OF CERTAIN BIRDS IN RICE FIELDS

1. Pipit, 2. Skylark, 3. Little ringed plover, 5. Snipe, 6. Blackwinged stilt, 7. Pond heron, 8. Cattle egret, 9. Little egret, 10. Baya weaverbird, 11. Bluethroat, 12. Bluebreasted banded rail, 13. Paddyfield warbler, 14. Streaked fantail warbler, 15. Nest of streaked fantail warbler, 16. Indian wren-warbler, 17. Nest of Indian wren-warbler, 18. Munias, 19. Roseringed parakeet, 20. Red munia, 21. Painted snipe, 22. Blue rock pigeon, 23. Redheaded merlin, 24. Black drongo, 25. Brown shrike, 26. Marsh harrier, 27. Swallow, 28. Whitebreasted Kingfisher, 29. Small green bee-eater, 30. Brahminy Kite.



Plate 9 : Blackwinged Stilt a migrant wader invading open, inundated fields.



Plate 10 : Whitebreasted waterhen, a breeding resident at HBL and a minor pest of rice.

the plots to feed on the grain. They fed on the grain from grain filling stage to maturity. The little egrets disappeared from the field after late tillering stage, but the cattle egrets readily took to foraging in plots that had crops of flowering, grain filling/maturing stage. They picked up insects flushed out into air, by their own movement through the dense growth of paddy plants. In addition the foliage dependent species such as the warblers continued to be active at this stage of crop. Similarly, the insectivores like the drongo, bush chat and spotted owlet, continued to be present (Appendix - IV, Fig.7).

Ground foragers were found from second to sixth successive field stages, after the harvest. The herons, egrets, lapwing, snipes, wagtails made their appearance. Blue rock pigeons, parakeets and whitethroated munias fed on the fallen grains of paddy, while, the wagtails to fed on insects lurking among the stubbles of cut plants.

The harvested plots left inundated for a week stimulated the stubbles to put-forth sprouts attracting sandpipers, specially snipes, egrets (Plate - 11) and pheasanttailed jacanas (as in NGR). When these plots were left to dry, they attracted pipits larks, cattle egrets and occasionally Indian rollers (Plate 12) scanned these dry plots for food.

4.5.1 Seasonality and Abundance of birds in rice fields

Seasonality and abundance of birds observed in the three study areas are depicted in Fig. 8,9. and 10. The details of the frequency

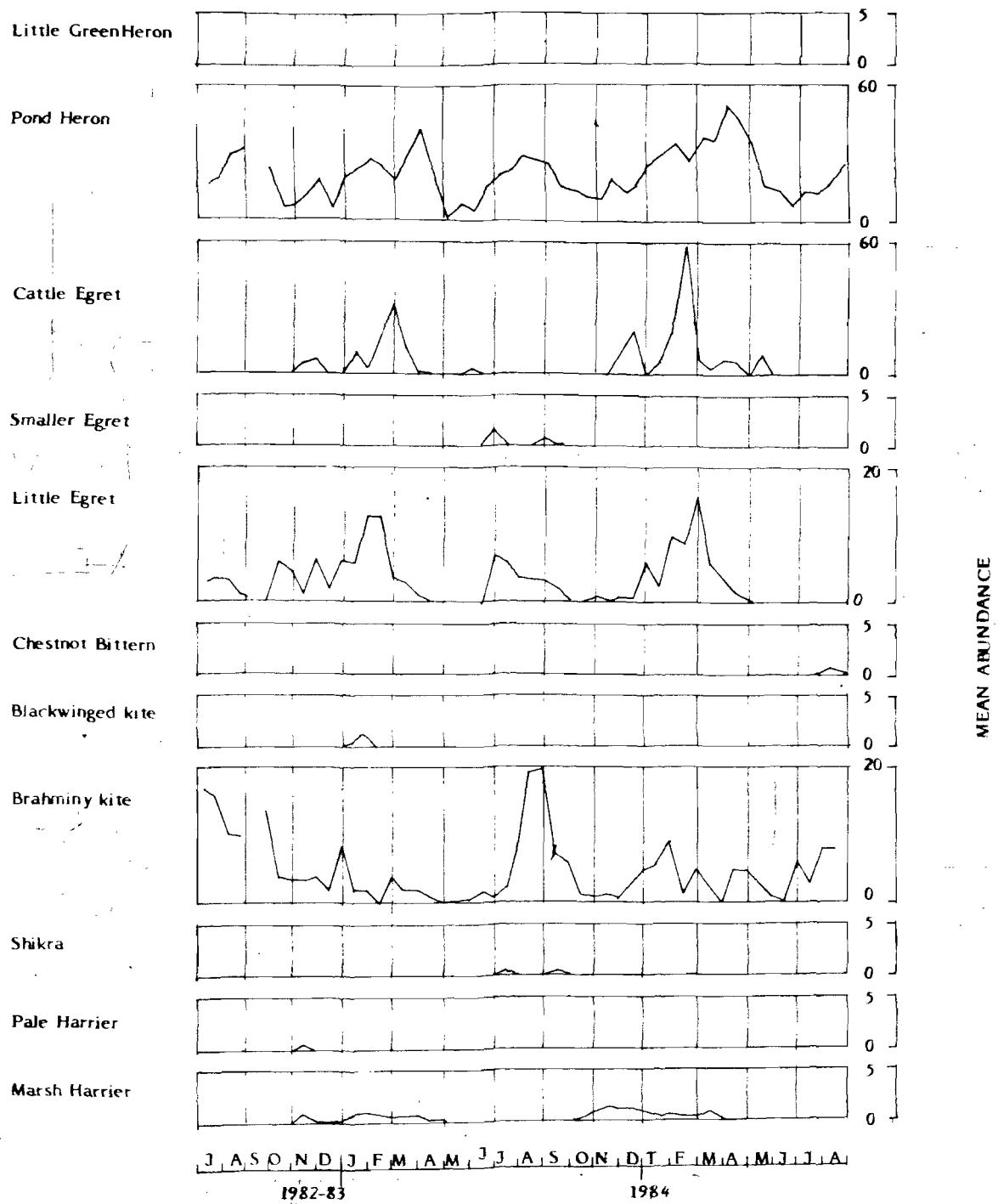


Fig. 8. Seasonal population fluctuations of birds at Hebhal area.

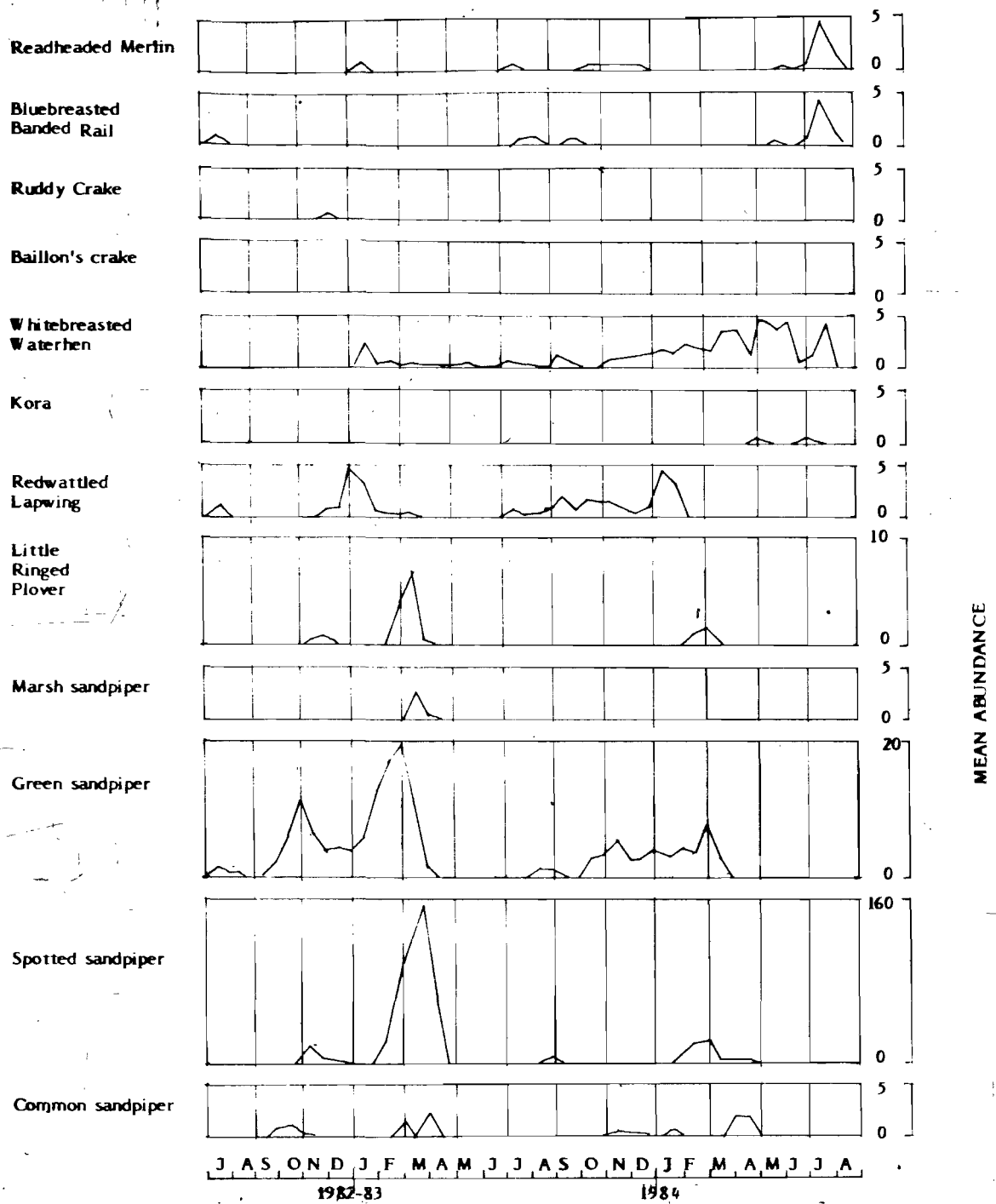


Fig. 8

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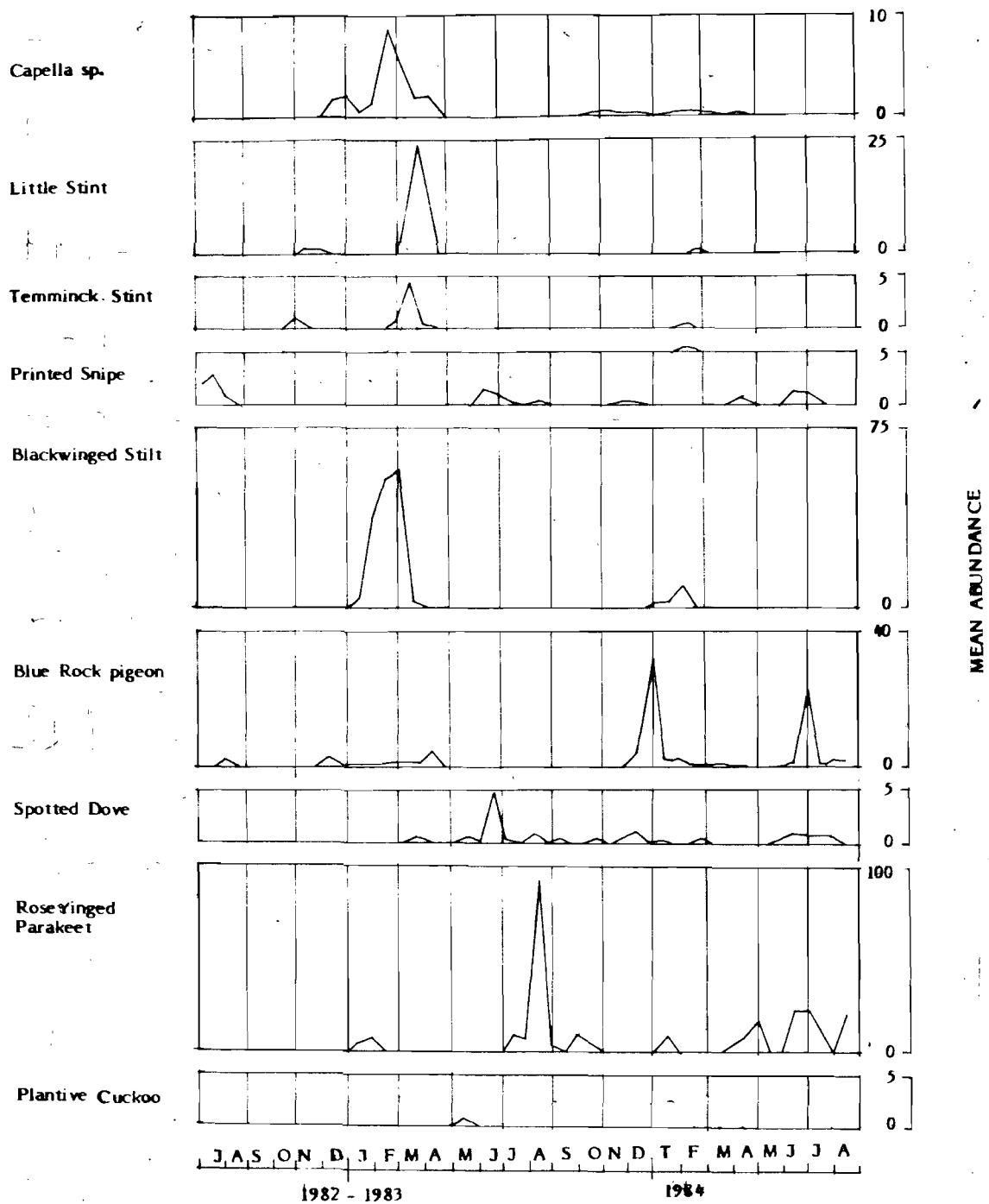


Fig. 8

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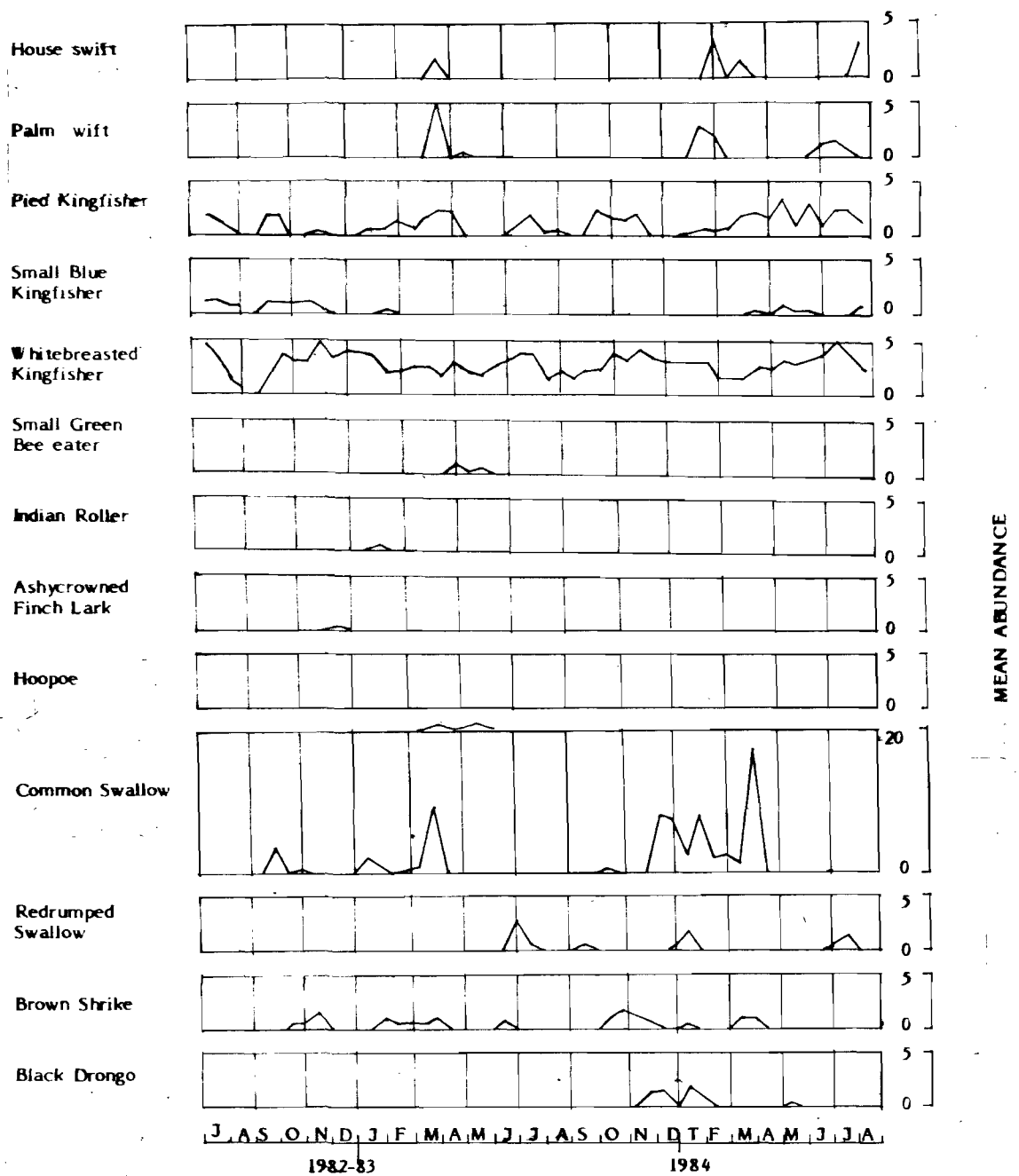


Fig. 8

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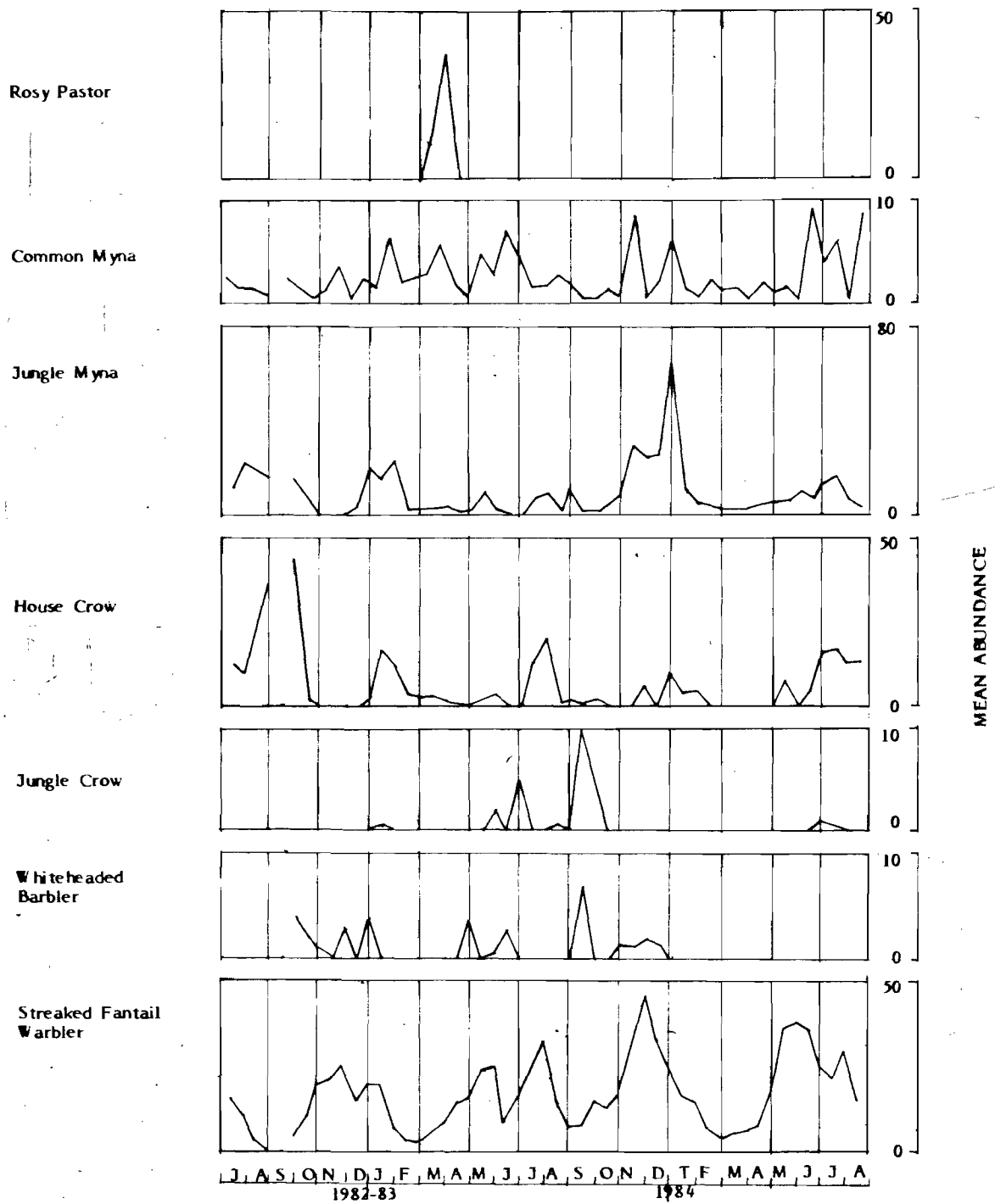


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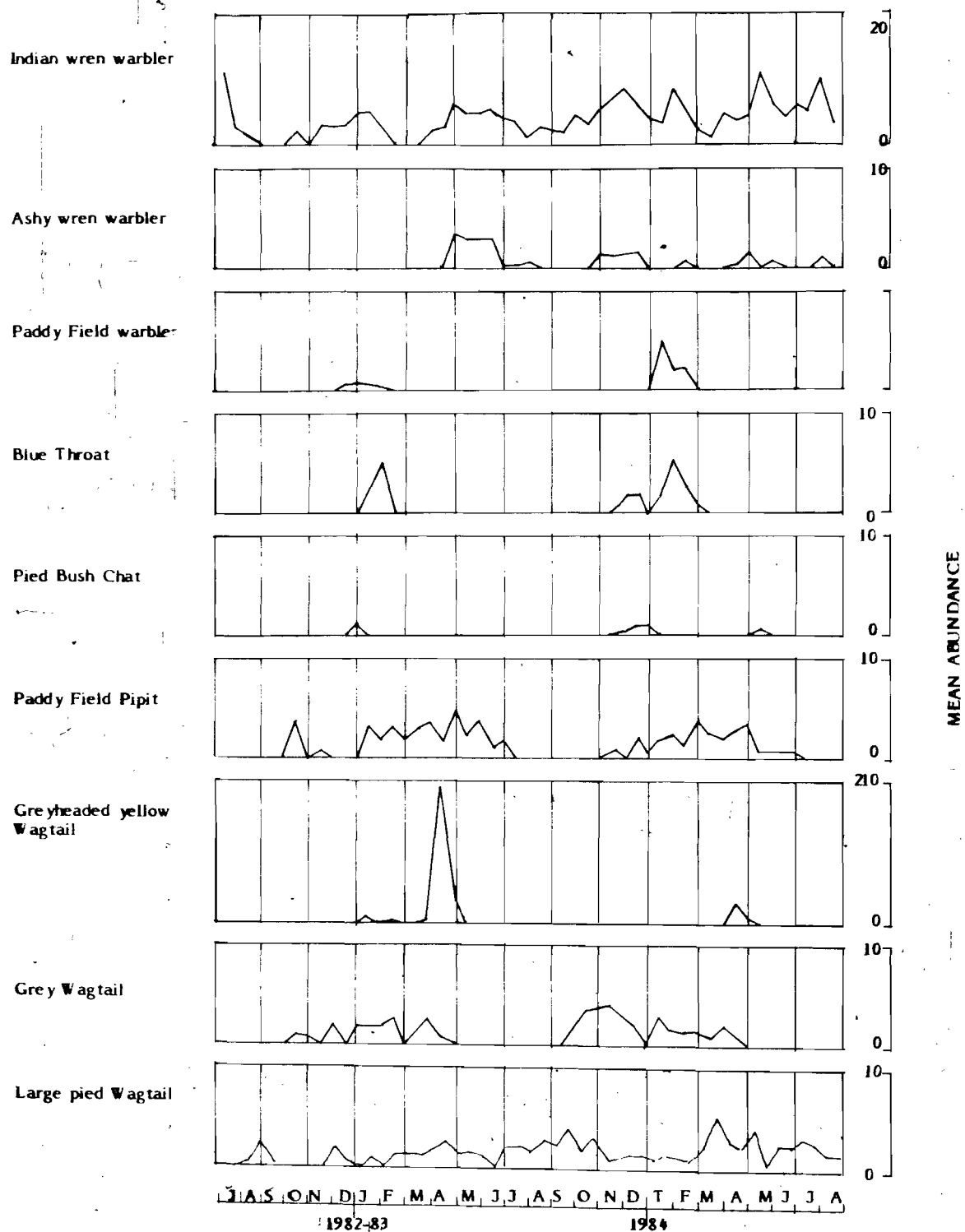


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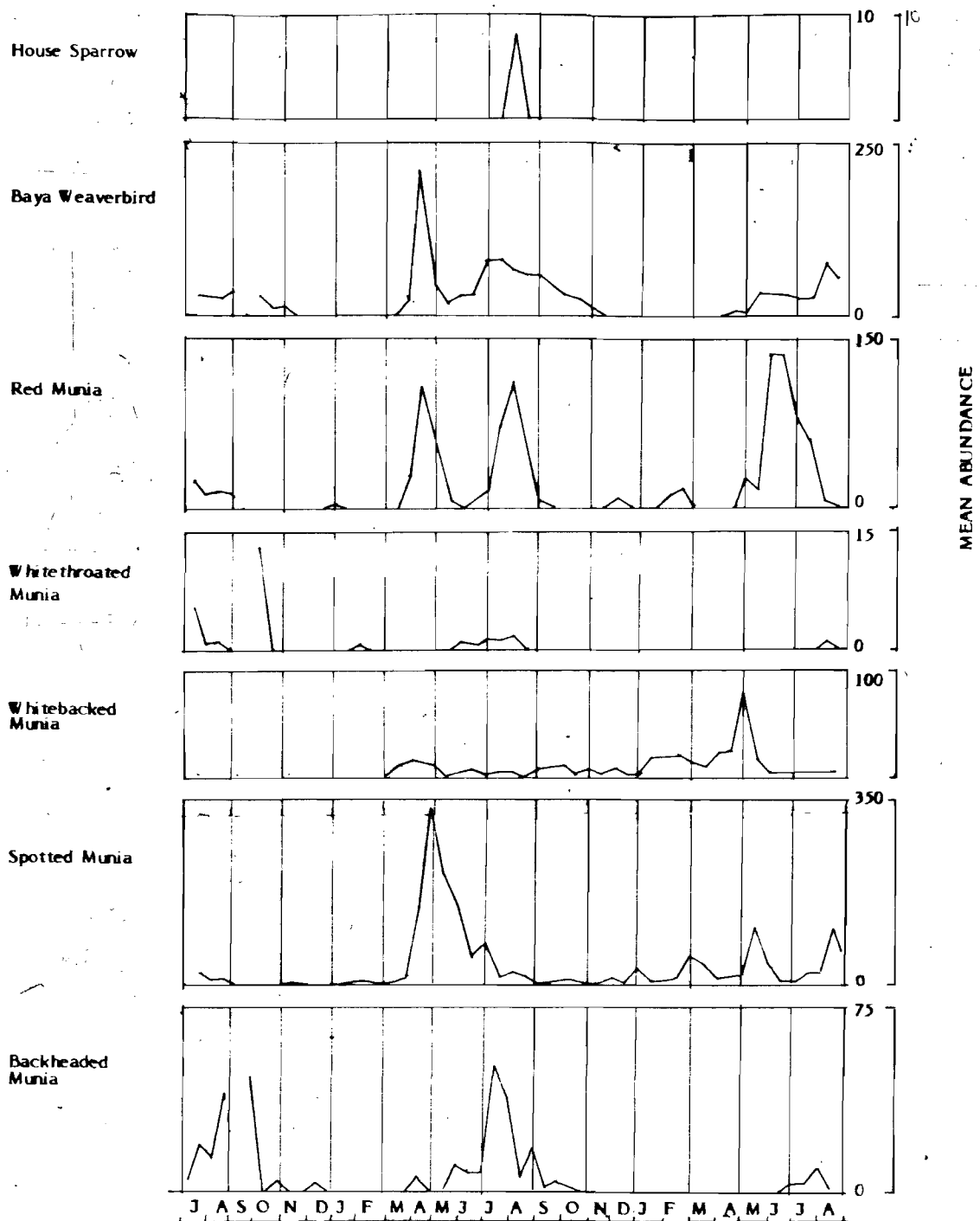


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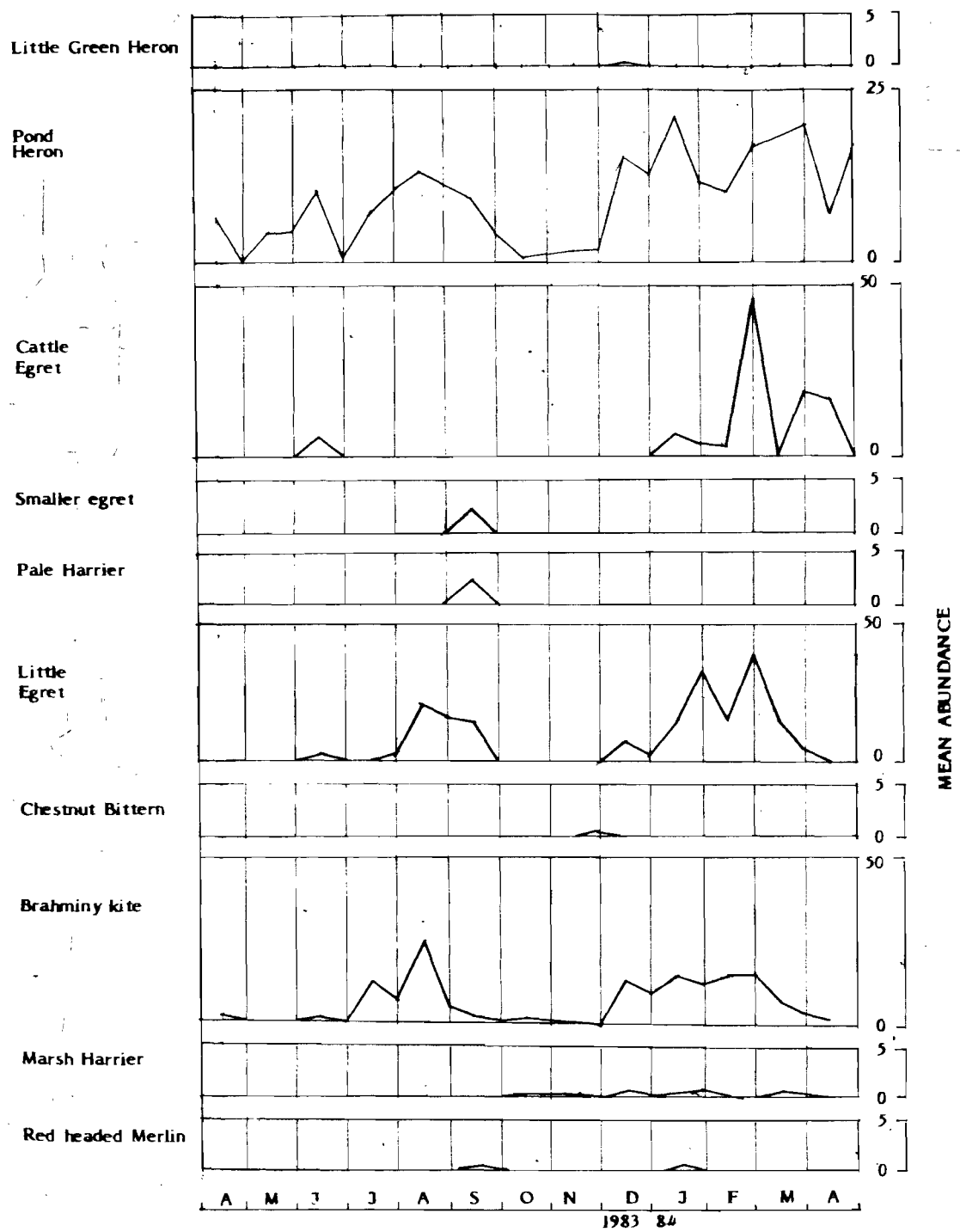


Fig. 9. Seasonal population fluctuations of birds at Nagavara area.

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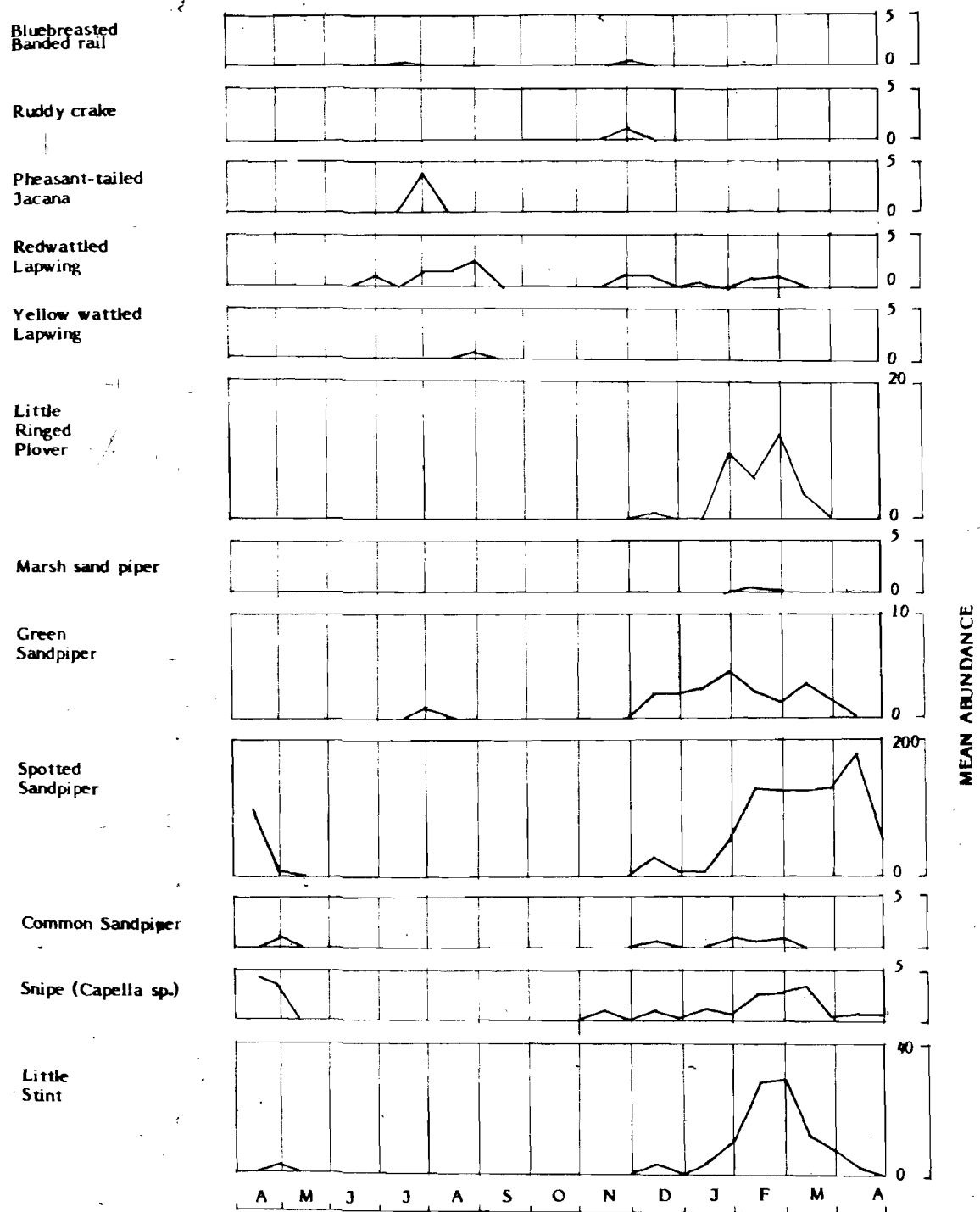


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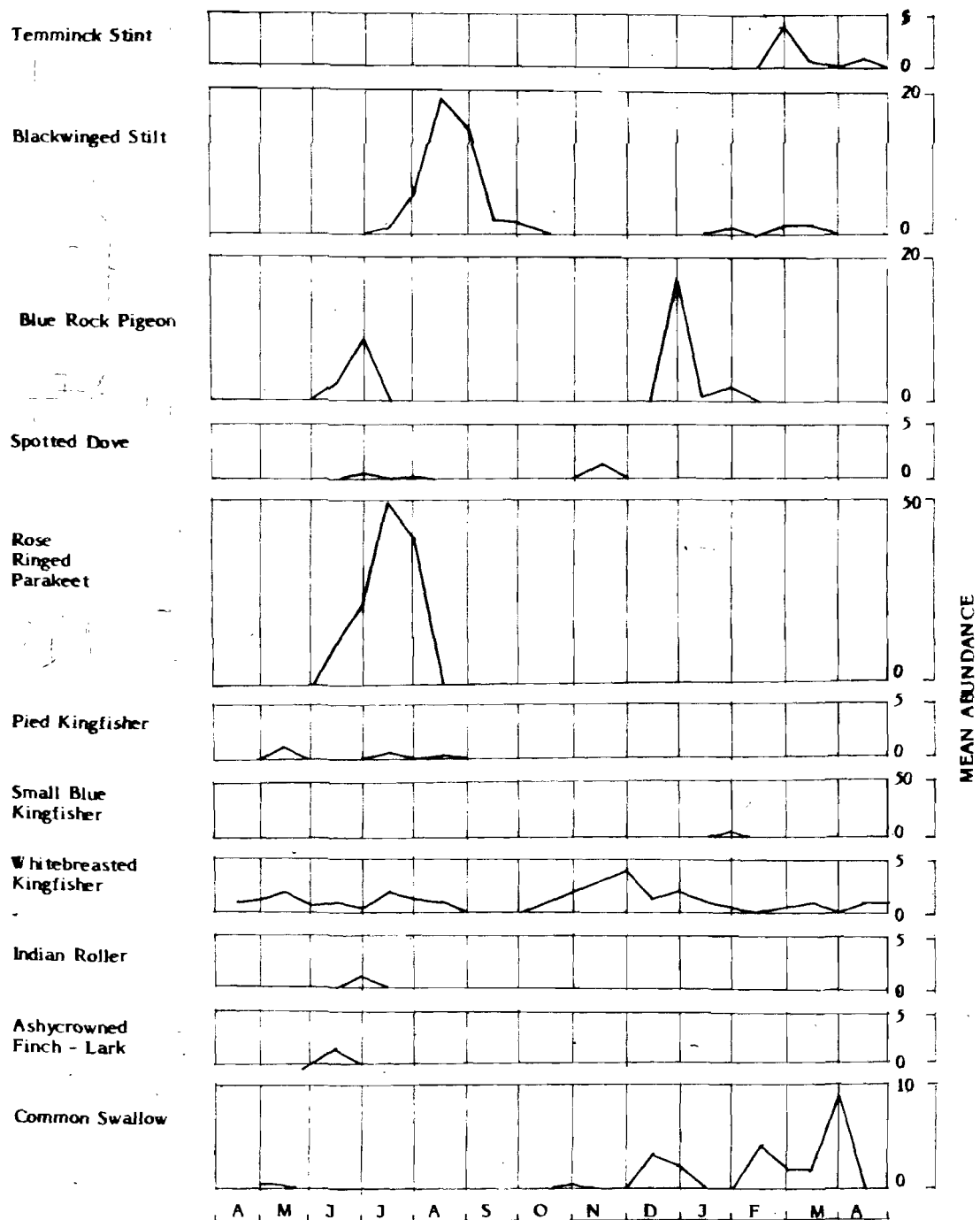


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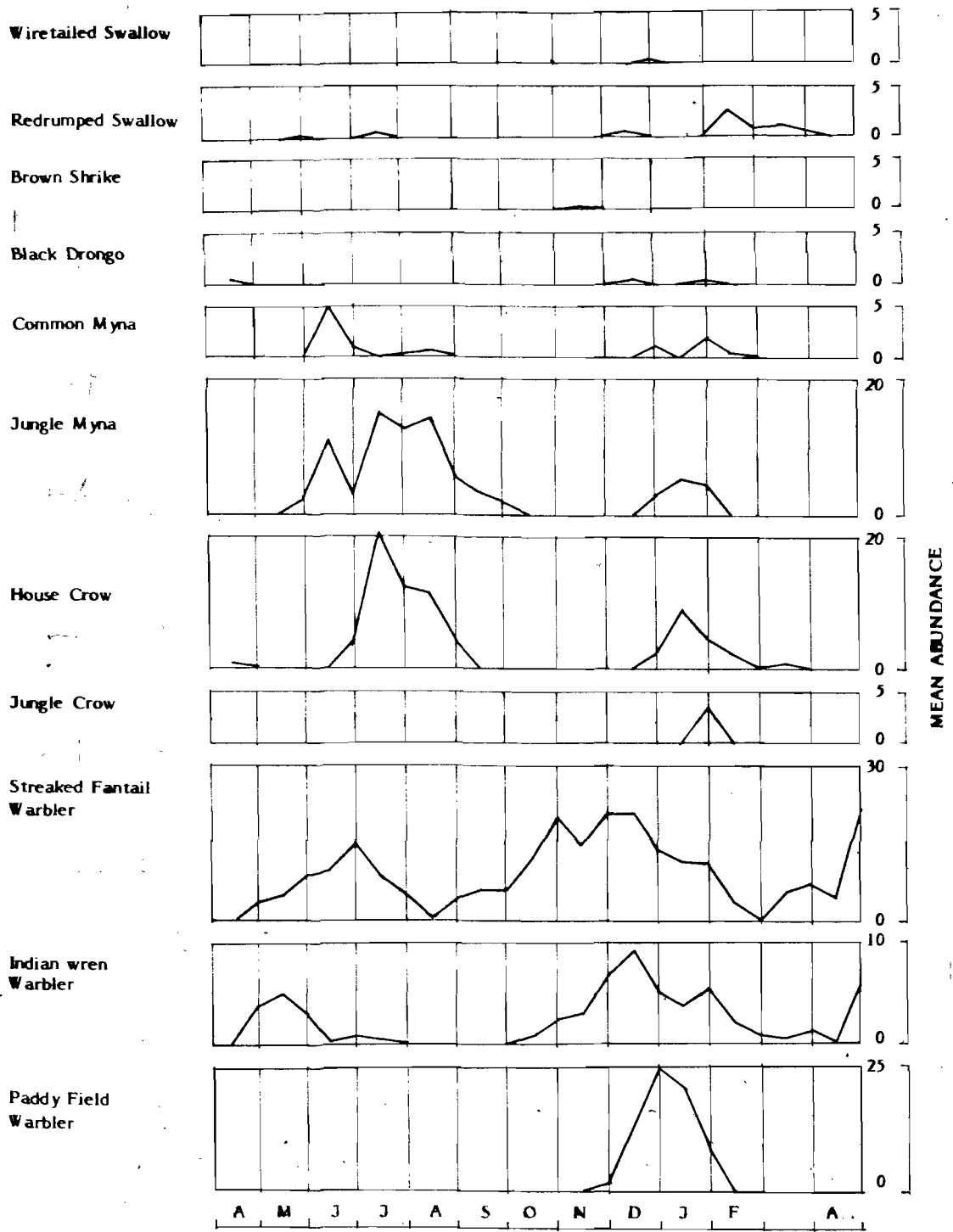


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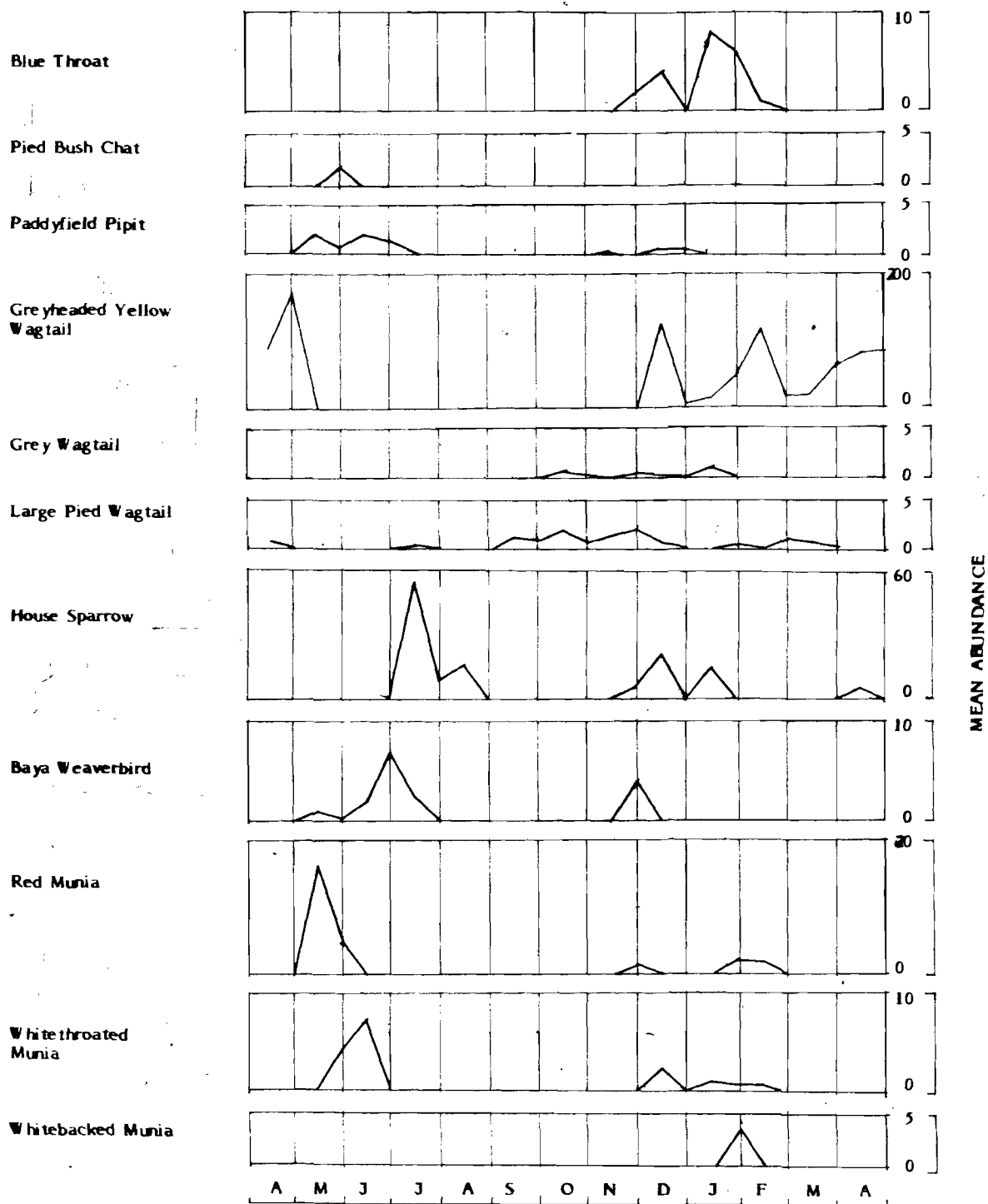


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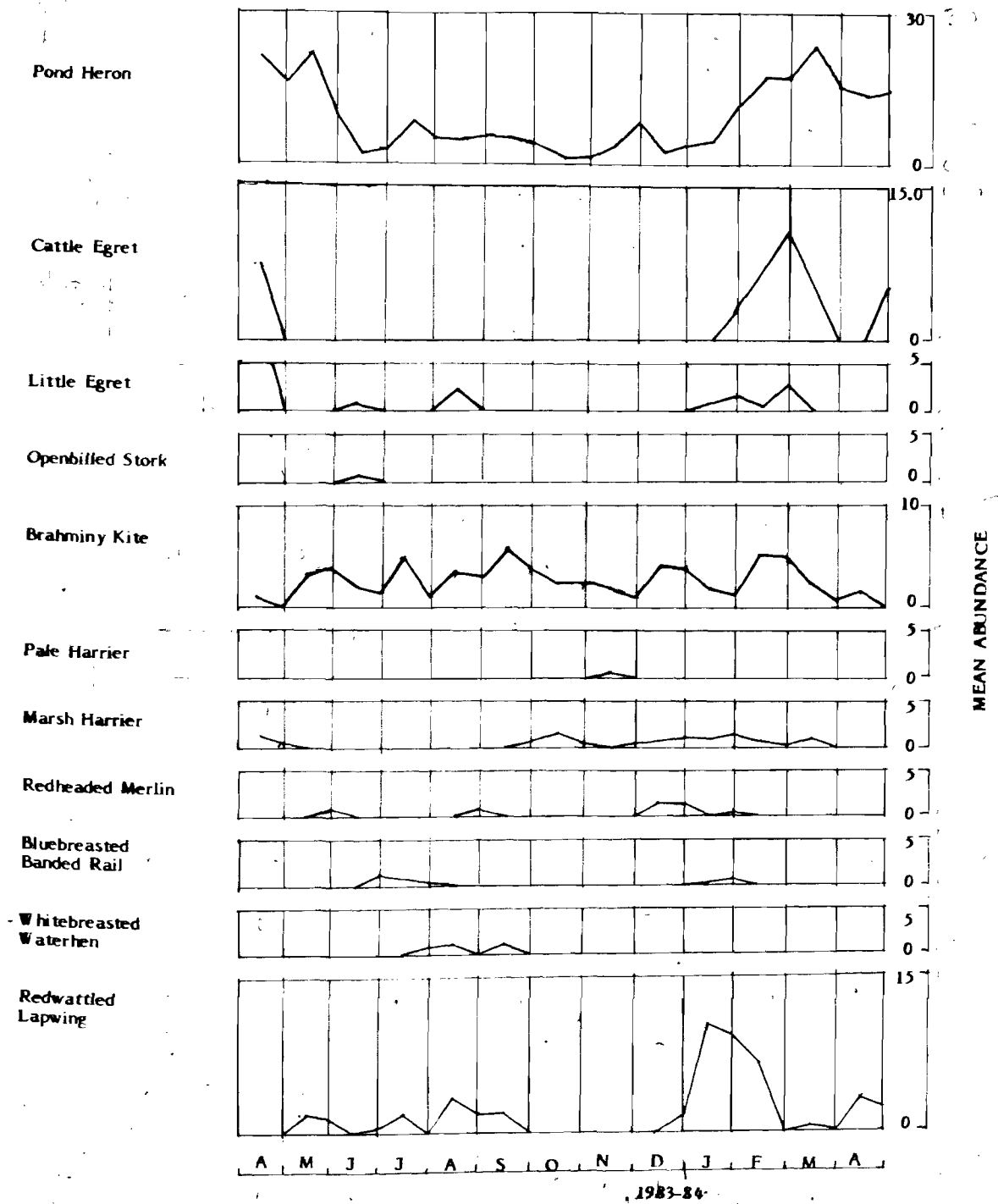


Fig. 10. Seasonal population fluctuations of birds at Kodigehalli area.

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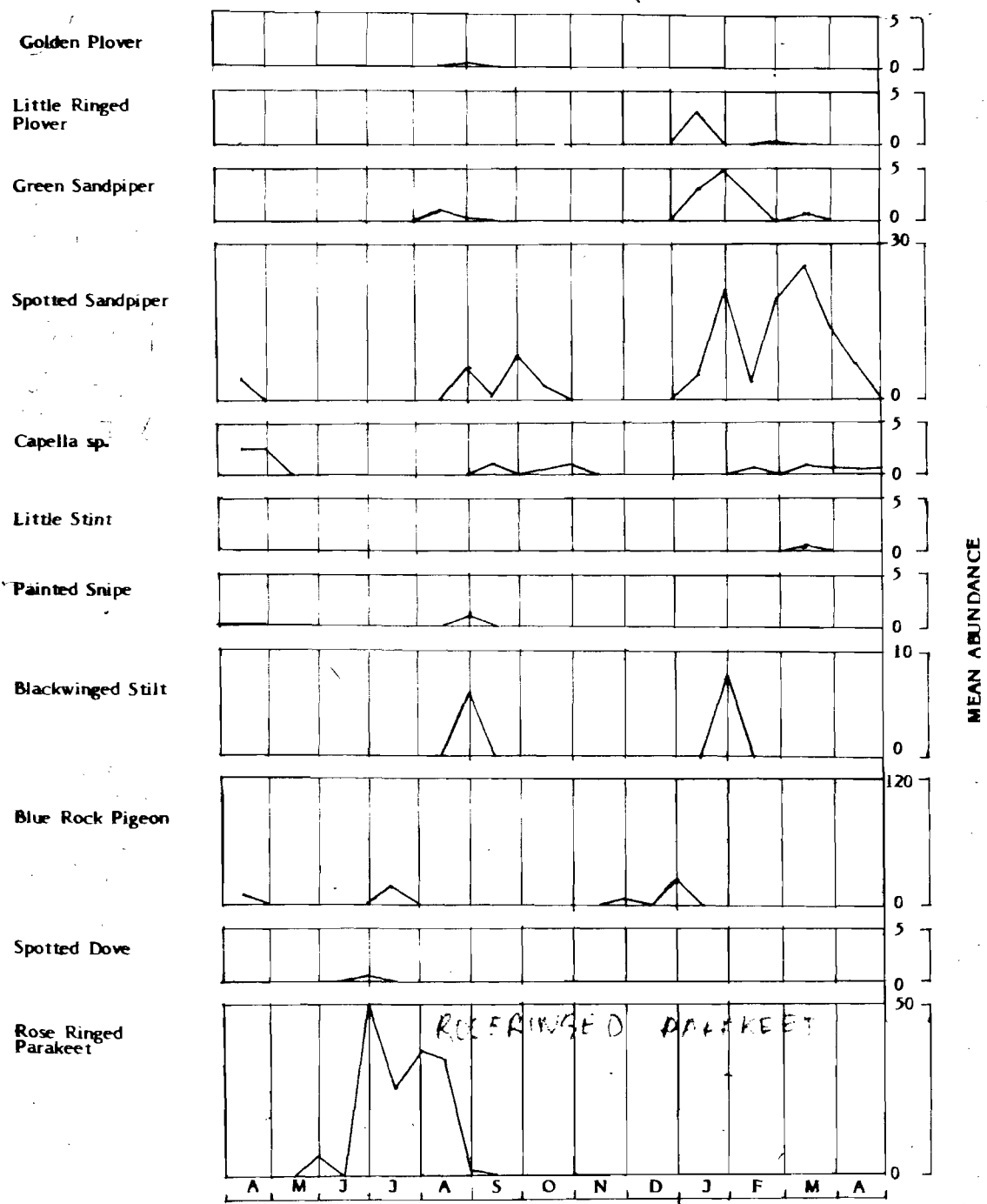


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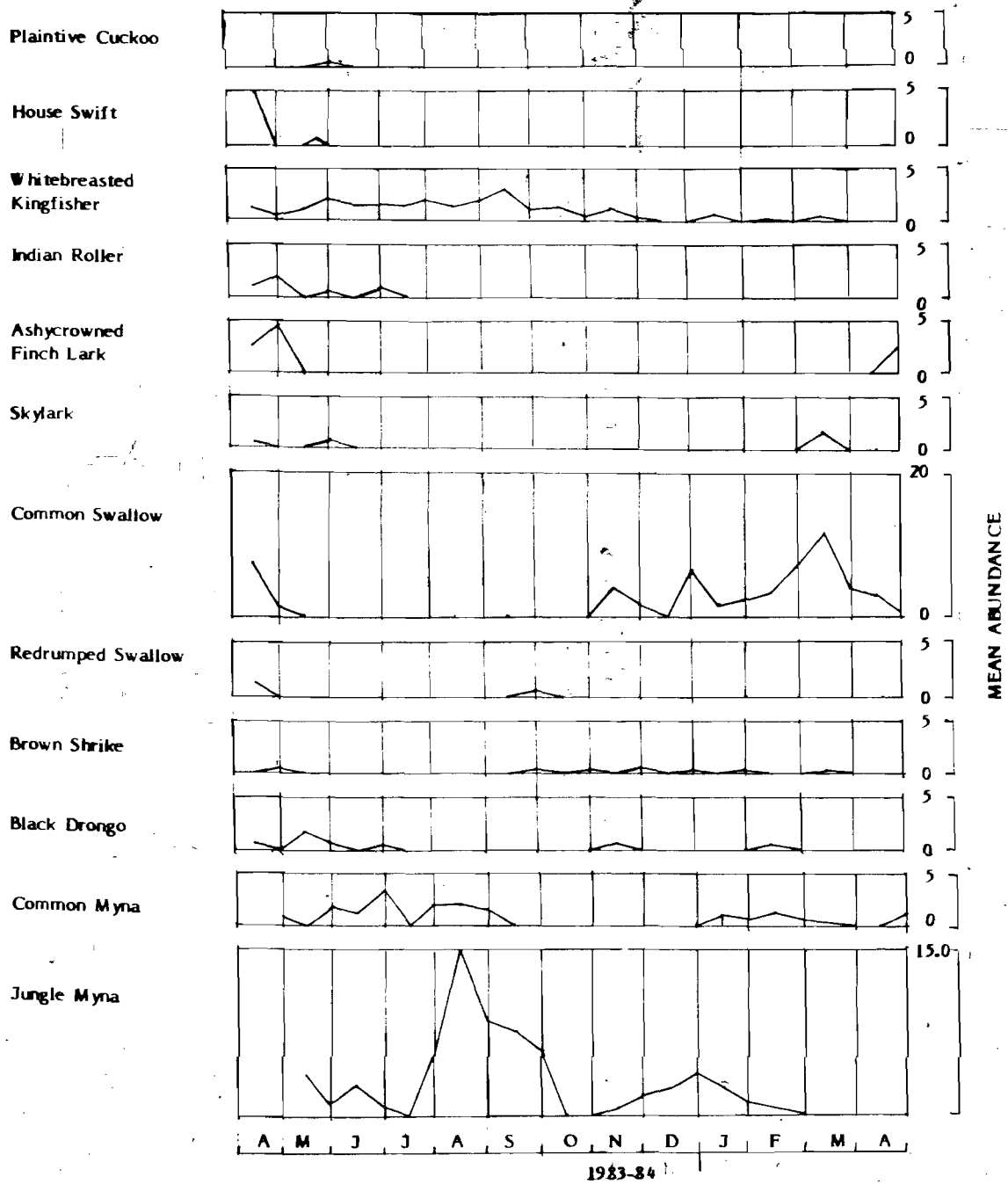


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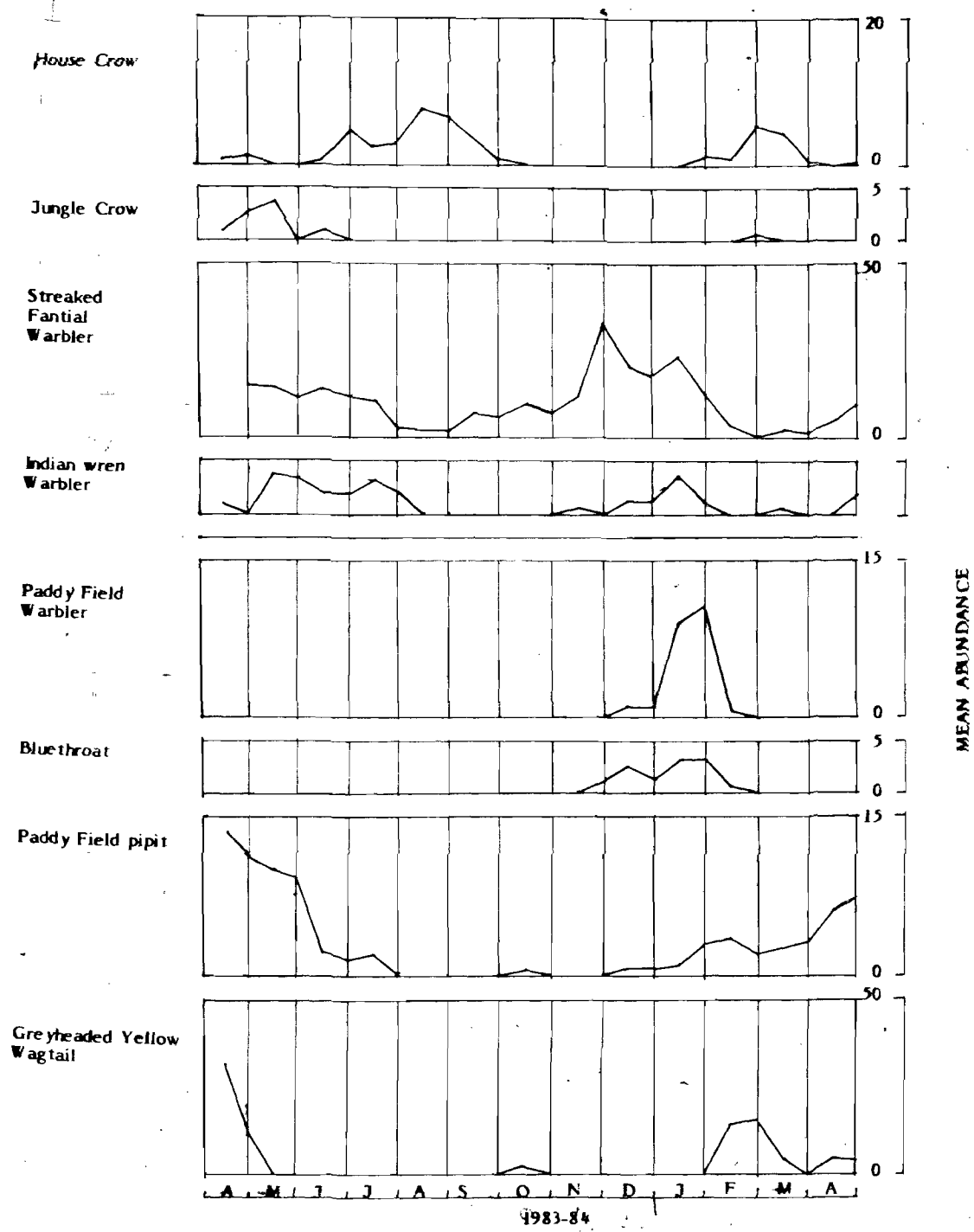


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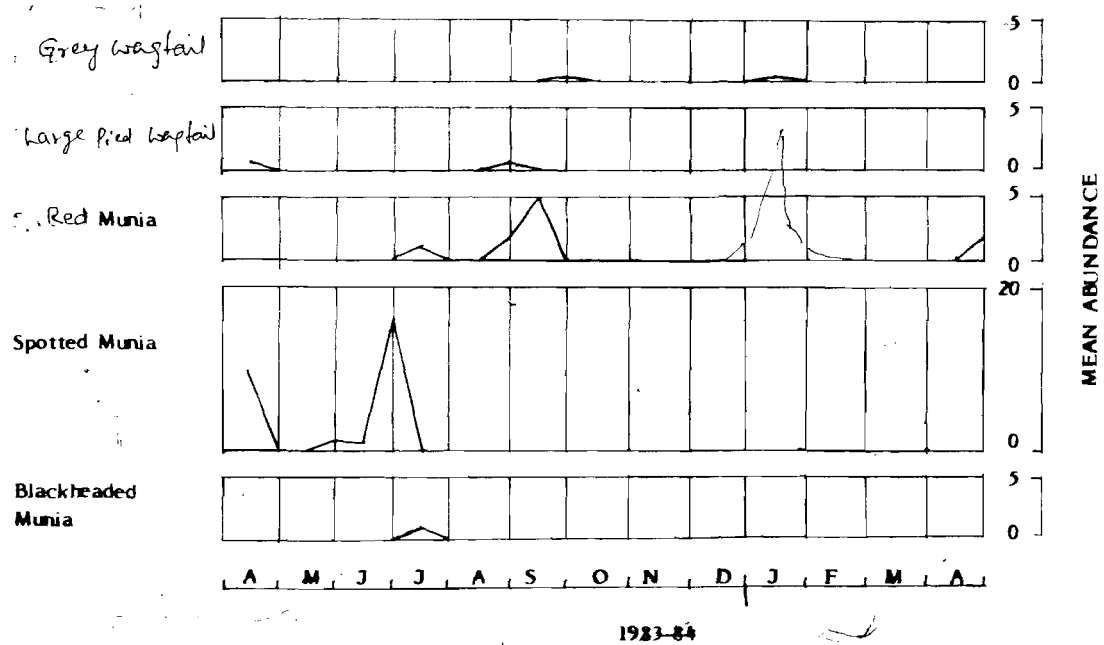


Fig. 10

of sightings (out of 162 census at HBL (July 1982 to August 1984); 78 census at NGR (April 1983 - April 1984); and 77 census at KGH (April 1983-1984)), maximum number of birds recorded per census and the month in which mean fortnightly maximum for each of the study areas is presented in Appendix V.

Hérons

1. **Little green herons :** It was sighted in flight only once each at NGR and HBL during December 1983. At NGR the bird took to wings from a plot with standing rice.
2. **Pond herons :** Present throughout the study period at all the three locations. The peak (40.57 and 51) population during March in 1983 and 1984 at Hebbal whereas at NGR it was in January 1984 (21.0) and in May at KGH (22.25). At HBL as many as 69 birds per census was recorded in March while it was 35 and 34 at NGR and KGH, respectively. They were recorded on 161 censuses at HBL and it was 66 and 70 at NGR and at KGH.
3. **Cattle egret :** Although seen in almost all the months during the period of study, the peak was in January 1984 (57.40) at HBL, February 1984 at NGR and in April 1983 at KGH (11.0). The maximum flock size of this bird was 116 at HBL, 59 at NGR and 33 at KGH area.

4. **Smaller egret :** The mean fortnightly maximum was 6.0 (June 1983) at HBL, 2.33 (September 1983) at NGR and none at KGR. They were less abundant among egrets.

5. **Little egret :** The mean fortnightly maximum at HBL, NGR and KGH was 12.78, 15.50 and 11.00 during January 1983, February 1984 and February 1984, respectively. The maximum per census was 33, 25 and 6 at HBL, NGR and KGH, respectively.

Birds of Prey

1. **Brahminy Kite :** It was present throughout the year at all the study areas. The fortnightly peak population in all the three areas was during August, September 1984 and it was 20.0 (HBL), 24.0 (NGR) and 6.0 (KGH).

2. **Shikra :** It was recorded thrice, as single individuals each time at HBL area only during July-August 1983.

3. **Pale harrier :** Individuals of this species was recorded twice at HBL (winter 1982), once at KGH (November, 1983) and none at NGR.

4. **Marsh harrier :** This species was most frequent among birds of prey next to brahminy kites. At HBL it was regularly seen in low number (less than 3) from October to April. At NGR and KGH areas its abundance was less than one and a maximum of four per census. Marsh harriers was seen frequenting the study areas from October onwards and was not seen after April.

5. **Redheaded Merlin :** This falcon was seen either singly or in pairs and was considered as resident irregular. This falcon was sighted on 13 occasions at HBL and it was sighted on 6 and 2 occasions at KGH and NGR, respectively.

Rails

1. **Bluebreasted banded rail :** This rail was mostly seen singly or in pairs and was common from June to August at HBL and NGR. At KGH area they were seen only at during July 1983 and January 1984. A mean maximum of 4.0 was noticed at HBL during July 1984.

2. **Baillon's crane :** Two birds were recorded only once at HBL during December 1982.

3. **Whitebreasted waterhen :** It was the most abundant of the rails at HBL area from July onwards and was maximum (4.61) during June 1984, where several family parties of four to seven birds could be seen, often raising the number of birds per census to 16. They were sighted only in June-July of 1983 at KGH. None at NGR.

4. **Ruddy crane :** This species was recorded more frequently at HBL while, only once at NGR during November 1983 and none at KGH. A mean maximum of 10.50 at HBL was during July 1984 and family parties of four of six birds were seen during this period.

5. **Kora or the watercock :** It was sighted singly only at HBL during April, June and July 1984.

Jacana

Pheasant-tailed jacana : Was sighted only on five occasions at NGR during the second half of July 1983, once with 11 foraging individuals.

Plovers

1. **Redwattled lapwing :** The species was recorded at all the study areas. It was seen when plots were being prepared at NGR. At KGH it was seen from May to September 1983 and again from January to March 1984 when this species was presumed to be breeding even though no nests were sighted. At HBL area the bird was seen from December 1982 - March 1983 and July 1983 - January 1984. The number of birds per census during these periods was of (HBL), 7 (NGR) and 17 at KGH. The mean fortnightly maximum at NGR in August area was less than three individuals, compared to 10.50 birds at KGH in January 1984. It was 4.5 at HBL.

2. **Yellow-wattled lapwing :** Was (Plate - 13) sighted in pairs only at NGR area in July and August 1983 during ploughing and puddling operations.

3. **Greyheaded lapwing :** Only a single bird was sighted at KGH area on 18th April 1983, foraging wet uncultivated plot and transplanted plots.

4. **Little ringed plover :** This plover was seen at all the study areas with mean maximum of 7.0 during February 1983 at HBL; 12.50

at NGR during February 1984 and 3.33 at KGH area during January 1984.

Sandpipers

1. **Marsh sandpiper :** It was found at HBL and NGR with a maximum of seven per census birds at a time at HBL (March 1983) and only once at NGR. Its activity coincided with the availability of transplanted plots.
2. **Green sandpiper :** It was seen in all the study areas from July to next April irregularly. The fortnightly mean was 16.60 at (HBL) compared to 4.50 and 4.75 (NGR and KGH) during February 1983 (Plate - 14).
3. **Spotted sandpiper :** This species was seen regularly from October, November to April at HBL with a mean maximum of 157.86 during March 1983. The bird was seen again regularly at NGR with mean maximum of 179.0 (April 1984) while the species was infrequently sighted at KGH with a mean maximum of 26.00 in March 1984. Flock sizes as large as 242 individuals per census was sighted at HBL, while it was 200 at NGR and 53 at KGH.
4. **Common sandpiper :** It was less common compared to green and spotted sandpipers with a fortnightly maximum of only 2.5 and one at HBL and NGR during April 1983. None were recorded at KGH area.



Plate 11 : A flock of Cattle and Little Egrets frequenting harvested, plot with weeds at Hebbal area



Plate 12 : Indian Roller, a bird that prefers to feed in dry uncultivated fields.



Plate 13 : Yellow-Wattled Lapwing, a resident irregular species recorded at Nagavara.

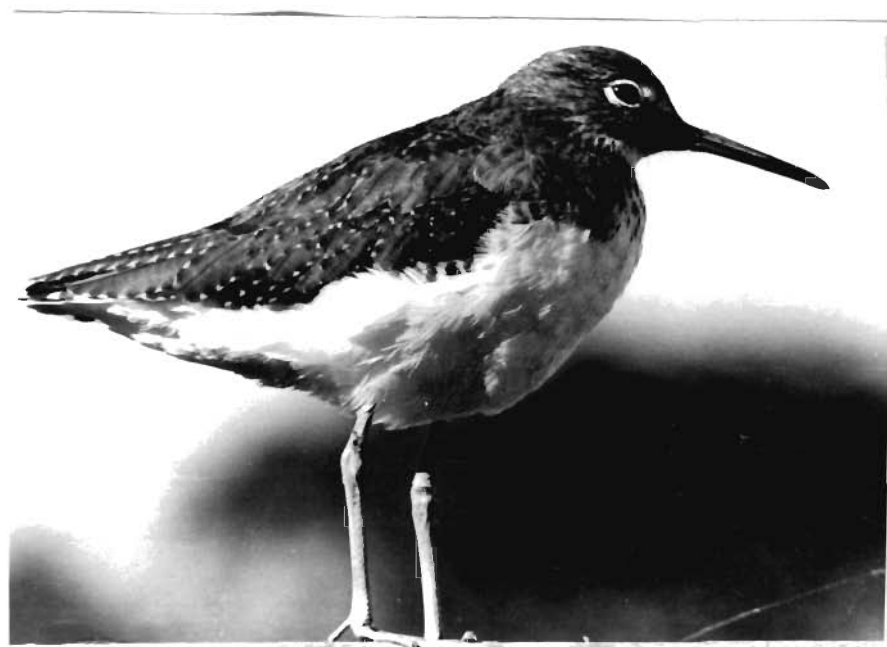


Plate 14 : Green Sandpiper, a palaerctic migrant that frequents inundated openfield conditions during winter.

Snipes

Capella sp : Recorded at the three study areas varied in the period of their occurrences. They were regularly seen at HBL with fortnightly mean maximum of 8.60 (February 1983). It was 4.5 and 2.5 at NGR and KGH during April 1983. Snipes were recorded 47 times at HBL (a maximum of 15 birds/census), on 24 censuses at NGR and 22 at KGH with a maximum of 6 and 3 birds per census.

Stints

1. **Little stint** : The mean maximum of Little stint population recorded was 24.33, 29.00 and 21.00 at HBL, NGR and KGH, respectively during February 1984 (HBL and NGR) and March at KGH. A flock comprising of 77 birds were once sighted at HBL, while the maximum bird number per census at NGR and KGH were 61 and 2 respectively.
2. **Temminck stint** : This species was less frequent visitor than little stints, with a mean maximum of 4.5 and 4.0 respectively at HBL and NGR and none at KGH. The bird was sighted on 9 occasions at HBL with a maximum number of 16 per census while, it was 4(8) and 2(3) at NGR and KGH respectively.

Painted snipe and stilts

1. **Painted Snipe** : It was not common at all three areas. It was sighted not more than a mean maximum of 10.0 at HBL (July 1984), only once at KGH and none at NGR. At HBL, 17 birds were recorded per census.

2. **Blackwinged stilt** : was most abundant (mean maximum 60.50) at HBL and below 10 at NGR and 17.33 at KGH. A flock of 100 birds was recorded once at HBL.

Gull

Brownheaded gull : This gull was seen only once at HBL area during January 1983 coinciding with preparatory cultivations. At NGR they were recorded during February and March 1984 when the plots were being ploughed and puddled. None were seen at KGH.

Pigeons and doves

1. **Blue rock pigeon** : The mean maximum of these birds was 120.67 at KGH in July 1983 compared to 31.00 and 17.33 at HBL and NGR respectively. This pigeon was recorded on 40 censuses at HBL with a flock of 88 birds once. At NGR the same figures were 8 and 52 while, they were 12 and 152 for KGH.

2 **Spotted dove** : This species was seen in small numbers with an average of less than two individuals per fortnight at all the three locations. At Kodigehally area this bird was recorded only once.

Parakeets

Roseringed parakeet : was (Plate - 15) most abundant during August 1983 when large numbers (fortnightly mean - 74.67) were recorded feeding on mature standing rice in partially harvested plots at HBL.

During other times they were found in small numbers feeding mostly in seeded nursery and freshly harvested plots.

The flocks which raided seeded nursery at KGH were as large as 153 birds, while the flocks that raided on standing crop as at HBL (only once) was as many as 201 birds.

Cuckoo

Plaintive cuckoo : An Individual Cuckoo was recorded at HBL and KGH areas during the second fortnight of May 1983.

Swifts

1. **House swift :** Was seen occasionally in the study areas. They were seen only during April 1983 and February-March of 1984 at HBL with a fortnightly maximum of 3.67 birds in February 1984. It was 6.25 during April 1983 at KGH and the maximum (2.67) at NGR during May 1983. At NGR and KGH areas flock sizes were of 16 and 15 birds, while it was 11 at HBL areas. House swifts were seen on less than four instances at any of the study areas.

2. **Palm swift :** Recorded only during April-May 1983 at HBL area with a fortnightly maximum of 5.67 during April 1983. This swift was not recorded at the other two study areas.

Kingfishers

1. **Pied kingfisher :** This species was recorded only at HBL



Plate 15 : Roseringed Parakeet, a pest of rice nurseries and standing rice.



Plate 16 : Whitebreasted Kingfisher, one of the important predator on crabs.

and NGR areas. This species was invariably seen perching on the electric wires passing over a fish pond at HBL area while it was seen close to a well at the edge of NGR area. A maximum of four birds per census was recorded and these birds were seen on 56 instances at HBL area and they were irregularly seen only on 3 occasions at NGR areas. The fortnightly mean maximum was less than 3.0 at HBL and the same was less than 2.0 at NGR.

2. **Small blue kingfisher :** Seen foraging singly or in pairs in irrigation nalas or fish pond at HBL area and were sighted on 18 instances. The bird was recorded only once at NGR area and none were recorded at KGH area.

3. **Whitebreasted Kingfisher :** (Plate - 16) was the commonest of the three species at HBL area and was recorded throughout the study period with a peak mean of 6.0 during July 1984 except for few months. It was present at NGR and KGH area throughout the study period (on 64 and 67 censuses). The fortnightly means was three at both the areas.

Bee-eater

Small green bee-eater : This bee-eater was never seen more than once. It was recorded thrice at HBL and only at NGR area. None were recorded at KGH.

Roller

Indian roller : was usually seen singly at HBL during January-February; September-October and December of 1983. At KGH area the bird was recorded 10 times from April-June 1983. None were recorded at NGR area.

Hoopoe

Hoopoe : was found feeding on bunds or at the edges of the study area singly at HBL (Plate - 17) during April-May 1983.

Larks

1. **Ashycrowned finch lark :** It was abundant at KGH, having sighted on 10 instances during study area compared to once both at HBL and KGH areas. A maximum of three individuals were recorded during June 1983 at NGR, while five individuals at KGH area.

2. **Skylark :** was seen four times only at KGH during their nesting period (April-May 1983 and March 1984) with a mean maximum of 1.67.

Swallows

1. **Common swallow :** (Plate - 18) Frequented at all the study areas from September onwards till next April. Fortnightly peak was 17.66, 87.33 and 11.67 for HBL, NGR and KGH, respectively during March 1983.

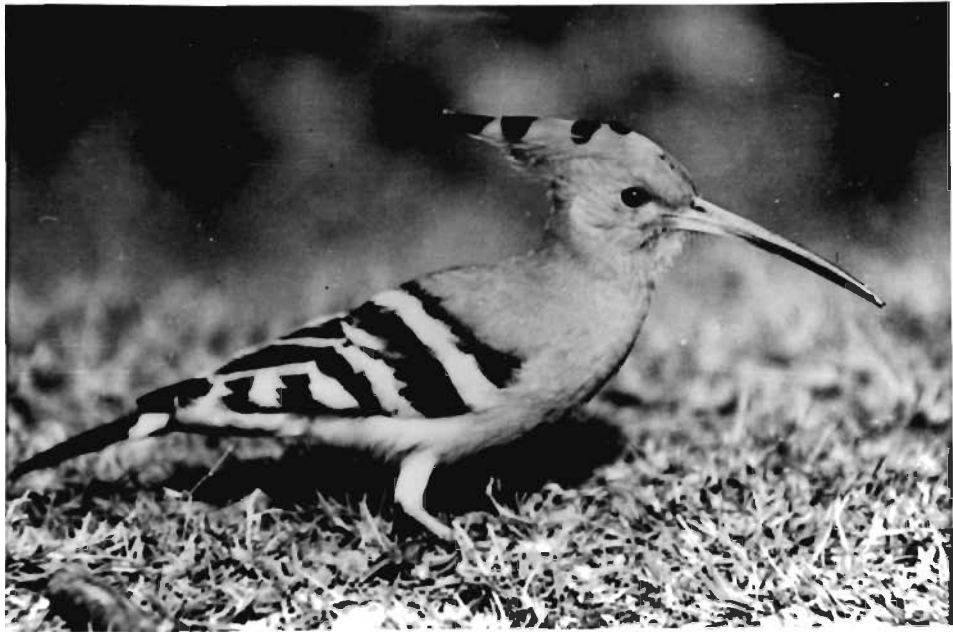


Plate 17 : Hoopoe, a resident irregular visitor to rice fields.

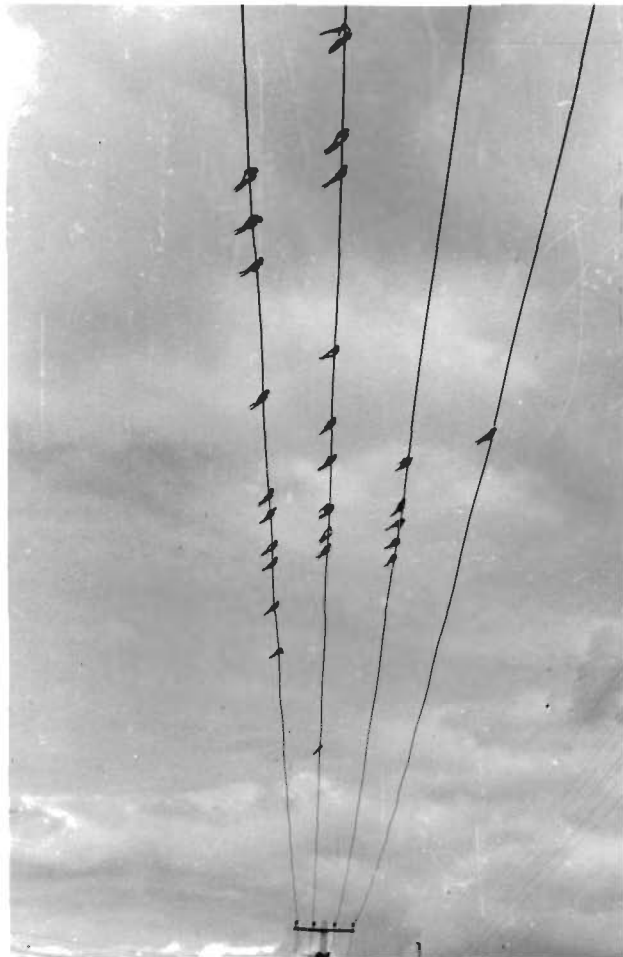


Plate 18 : Migrant Common Swallows resting on overhanging electric wires at Nagavara.

2. **Wiretailed swallow :** was recorded singly at HBL and NGR but not at KGH.

3. **Redrumped swallows :** was maximum (mean 3.0) during June 1983 at HBL and was less abundant at NGR and KGH areas (2.75) (February 1984) and 1.25 (April 1983), respectively. The birds were recorded on five instances at HBL area and on ten and three instances, respectively at NGR and KGH areas.

Shrikes and Drongos

Brown shrike : Although occur singly, yet upto three individuals per census were seen at HBL. They were seen once at NGR during 1983 and at KGH singly during April 1983, September 1983-March 1984. The shrikes always took to the tree line or bushes as shelter.

Black drongo : was seen usually singly at HBL (Plate - 19) At NGR drongos were seen only during April and December 1983, while at KGH it was during April-June and November 1983 and again during 1984.

Mynas

1. **Rosy pastors :** In flocks of upto 224 birds were seen at HBL area during March 1983. They were not seen again.

2. **Common myna :** was regularly seen in small numbers of 1-3 individuals. A flock of 29 birds were once seen when preparatory cultivations at HBL. At NGR and KGH their activity coincided with

land preparations.

3. **Jungle myna** : was abundant of the three species and was seen 26 and 27 times at NGR and KGH respectively. At HBL they were more regular and were sighted 112 times.

Crows

1. **House crow** : This species was seen almost throughout the year at HBL with peak activity coinciding with preparatory cultivations and harvesting operations. They also foraged among stubbles. The species was recorded during preparatory cultivations at NGR and KGH but in low numbers. The fortnightly peaks were 43.00 (September 1982), 16.00 (July 1983) and 14.00 (September 1983), respectively, for HBL, NGR and KGH.

2. **Jungle crow** : Even though this species was recorded irregularly in all the study areas, fortnightly peaks of 10.0 (HBL, September 1983) and 5.0 each was recorded at NGR (February 1984) and KGH (May 1983), respectively. The species was recorded on five instances at HBL and KGH and once at NGR.

Babblers

Whiteheaded babbler : This species was recorded only at HBL area on six instances during the study period with a maximum flock size of five individuals in June 1983.

Warblers

1. **Streaked fantail warbler** : was observed on 149 instances at HBL, 65 at KGH and 66 at NGR. On standing paddy crop and was absent when no paddy was available. During these periods the maximum birds per census was 59 (November) 43, (April), and 32 (November) at HBL, NGR and KGH, respectively.
2. **Indian wren-warbler** : was found in all the three study areas with peak means of 11.00 (HBL), 9.33 (NGR) and 4.00 (KGH) during July 1983 and May 1984, December 1983 and May 1984, respectively.
3. **Ashy wren-warbler** : was recorded 25 times only at HBL with a maximum of 4 birds per census during April 1983.
4. **Tailorbird** : was recorded only at HBL on four occasions with a maximum of two individuals.
5. **Great reed warbler** : was recorded singly twice during March 1983 only at HBL area.
6. **Blyth's reed warbler** : was seen only once at HBL during the winter.
7. **Paddyfield warbler** : (Plate - 20) was recorded from all the localities during January 1984 with maximum of 21 at HBL, 39 at NGR and 20 at KGH. Their activity was limited to November-February months when standing paddy crop was available.



Plate 19 : Black Drongo, an aerial foraging irregular resident in rice fields.



Plate 20 : Paddyfield warbler, a strongly seasonal palaeartic migrant insectivore.

Chats

1. **Bluethroat** : Occured during winter from November till next February. It was seen on 39, 14 and 14 occasions at HBL, NGR and KGH areas with a maximum of 8, 14 and 14, respectively.
2. **Pied Bush Chat** : was sighted 7 times compared to 15 and 10 times at KGH and NGR, with a maximum of 6.11 and 4.00, respectively.

Wagtails :

1. **Yellow wagtail** : was the most abundant of the wagtails, often its flock size reaching upto 660 individuals (as at HBL). Their mean fortnightly maximum were 206.67, 174.00 and 32.75 at HBL, NGR and KGH areas, respectively during winter.
2. **Grey wagtails** : was recordced with a maximum of 5, 2 and 2 at HBL, NGR and KGH, respectively.
3. **Large pied wagtail** : was seen regularly at HBL area (92 censuses) with a maximum of eight birds during November 1983. At NGR it was seen only on four instances with a mean (2.00) during October and November 1983 while at KGH it was 0.75.

Finches :

The population size of finches (sparrows, weaverbirds and munias) were not found to have a constant population size in any of

the study areas. They showed considerable seasonality in frequenting the study areas with an average flock size of 850 weaverbirds and munias started breaking up for breeding with the onset of monsoon. At HBL area these birds were less abundant after July-August. During 1982 the bird numbers started decreasing after August-September and low population prevailed till the end of February 1983. After this their populations were steadily on the increase, reaching a peak towards the end of March to early April. Though their population started to decrease after this, considerable number of these birds could be found till the middle of July 1983. Again the birds started to frequent the study area only after February 1984. Though their population was lower than previous year, the birds were abundant till the middle of July (Fig. 11) at HBL area.

At KGH area the birds were abundant from May-June 1983, rare to be seen till early December 1983. Their population again declined at the end of January 1984. However, the average bird number did not exceed 20 individuals. At NGR area the birds were more abundant than they were in KGH area. Again here, the birds were seen frequently from April-June, and decreased later till October 1983. From the middle of October 1983 onwards and till the end of November a fortnightly average of about 50 individuals was observed. Thereafter a number of less than 10 were present.

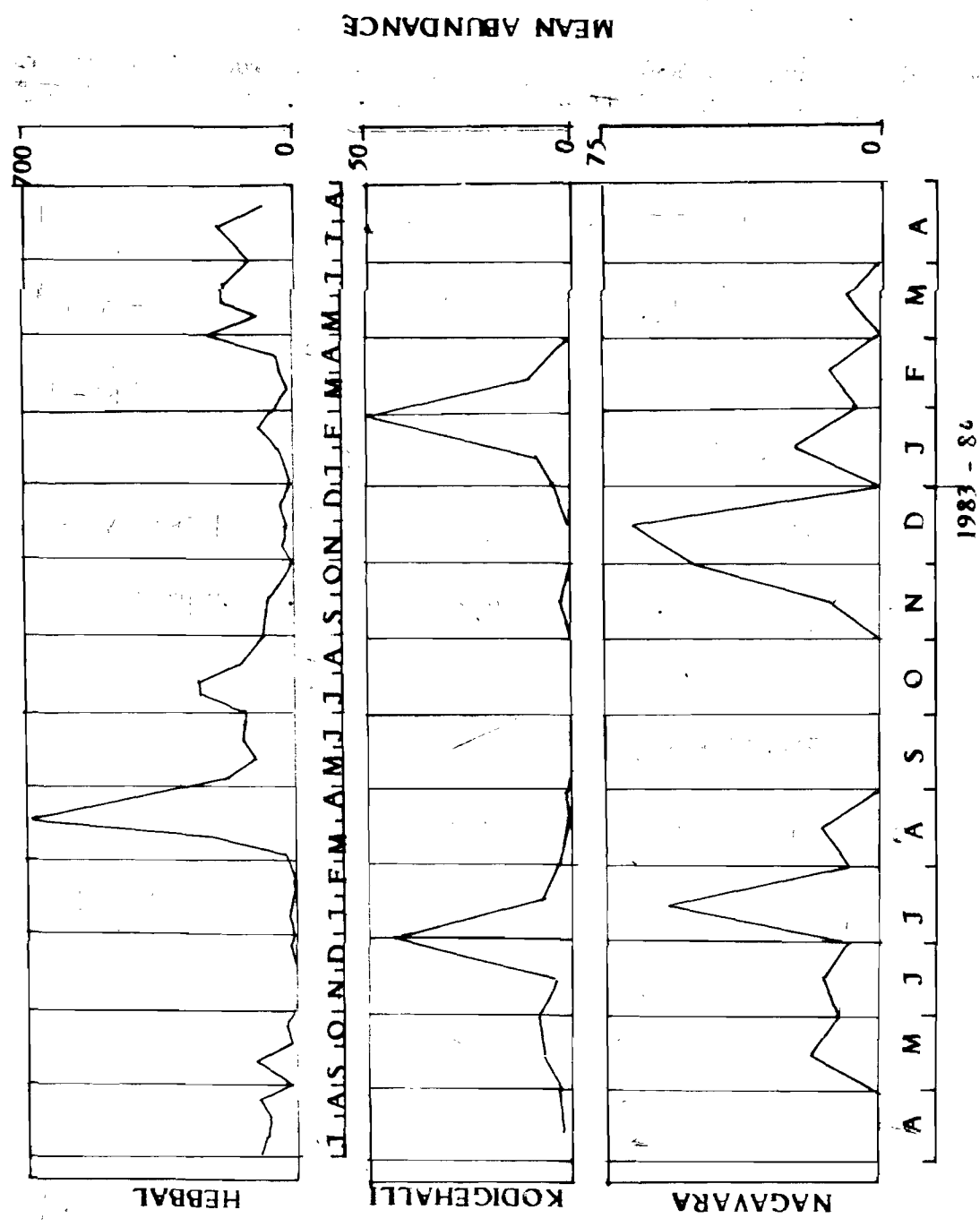


Fig. 11. Seasonal abundance of finch pests in different study areas.

1. **House Sparrow** : was seen 14 times at NGR with a maximum 142/flock compared to once at HBL with a flock of 33 birds. Sparrows were not recorded at KGH.
2. **Baya Weaverbird** : was seen in all the locations but more often at BHL (88 times) with a peak of 260 at HBL during April 1983. It was 7.0 and 5.0 times with a flock size of 8 and 14 at NGR and KGH respectively.
3. **Red Munia** : was recorded from all the study areas. The peak population was 260, 19, 26 at HBL, NGR and KGH with a frequency of 26, 6 and 18, respectively.
4. **Whitethroated Munia** : was sighted 18 and 10 times at HBL and NGR. The peak mean was 12.00 at HBL (July 1982) and 10.75 at NGR (February 1984). The species was not recorded at KGH.
5. **Whitebacked Munia** : was more common (85 census) and abundant (218 birds) at HBL. It was seen only once at NGR and none at KGH.
6. **Spotted Munia** : was the most abundant (94 census) of all the munias. At HBL its flock size went upto 670 birds per census. The same for NGR and KGH were 77 and 2 respectively with a frequency of 18 and 3, respectively.
7. **Blackheaded Munia** : was again most abundant (maximum

186) and common at HBL (56 instances) than other two areas. Three individuals of the species was recorded only once at KGH during July 1983.

4.5.2 Birds species diversity in the study areas

Hebbal area recorded the highest species diversity (12.924, Jan. '83) followed by NGR and KGH areas. The species richness/per census was also highest at HBL (39 spp.) followed again by NGR (32 spp. January 1984) and KGH (23 spp. January 1984) (Table 4). The species richness was high and was above the mean richness value during November 1983-April, 1983, June 1983 and again from October, 1983 to February, 1984 (Fig. 12 and Table 4).

The species diversity showed peaks during July-August 1982; October 1982 to next February, and again from October 1983 to February, 1984. The changes in the diversity when considered for the entire study period showed a low correlation with either richness or evenness. But the species abundant data was considered in two sets from July 1982, July 1983 and August 1983 to August 1984; there was a high correlation between diversity and richness during 1983 and 1984. (Table 4). A moderate correlation existed between diversity and evenness. There relationships were poorly correlated during 1982-1983 period at HBL.

Table 4. Details of the degree of correlation of species diversity with species richness and evenness and the corresponding mean values for the three study areas.

Hebbal Area

	Diversity (1982-83)	Diversity 1983-84
Richness	0.2771	0.7425
Evenness	0.2772	0.4101
Mean Richness :	24.843	
Mean Evenness :	0.655	
Mean Diversity:	6.770	

Nagavara

	Diversity	
Richness	0.7158	Mean Richness : 14.385
		Mean Evenness : 0.719
Evenness	0.5115	Mean Diversity : 5.689

Kodigehalli

	Diversity	
Richness	0.4544	Mean Richness : 16.538
Evenness	0.2380	Mean Evenness : 0.738
		Mean Diversity : 5.038

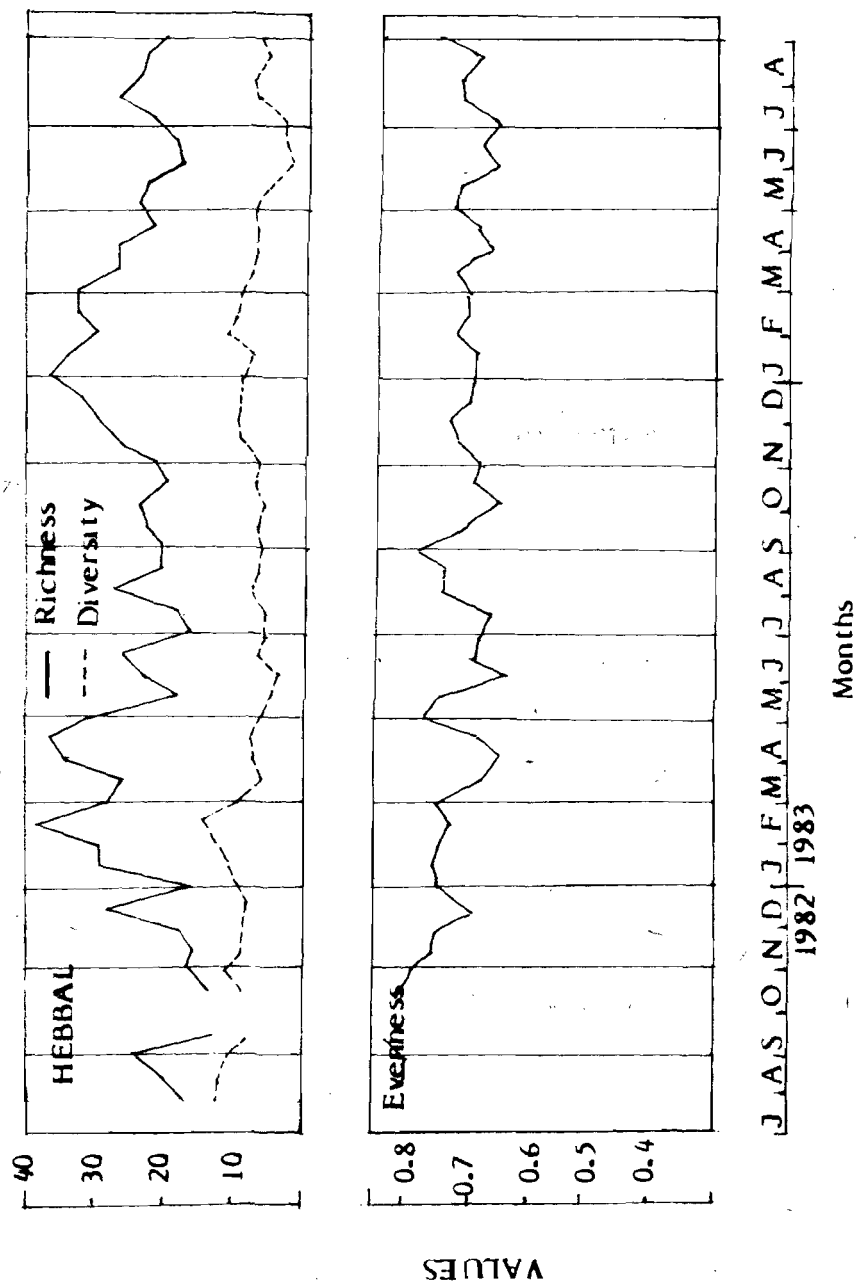


Fig. 12 Seasonal fluctuations in species richness, diversity and evenness at Hebbal area.

At NGR are high richness value was 32 (January 1984), while the lowest richness of 8 was recorded during September, 1983. The peaks in richness and diversity was recorded during April and August of 1983 and again from December 1983 to February March 1984 (Fig.13). The diversity was significantly correlated with both richness and evenness (Table 4).

At KGH area also the species diversity was positively correlated with species richness (Table 4) but it showed a low correlation with evenness. Both the richness and diversity showed peaks during December 1983 to February, March 1984 (Fig. 14).

4.6.1 Avian food web, food and feeding habits

Based on the types of food consumed, the birds visiting rice fields are classified into primary, secondary, and tertiary consumers and top carnivores. However, the species membership to these food groups and trophic levels often overlapped.

The primary consumers include only grain feeders. Thirteen species of birds from five families were observed feeding on grains from standing crop of paddy in the study areas. They were the white-breasted waterhen, spotted dove, blue rock pigeon, roseringed parakeet, whiteheaded babbler, house sparrow, baya and streaked weaverbirds, red munia, white-throated munia, whitebacked munia, spotted munia and the black-headed munia.

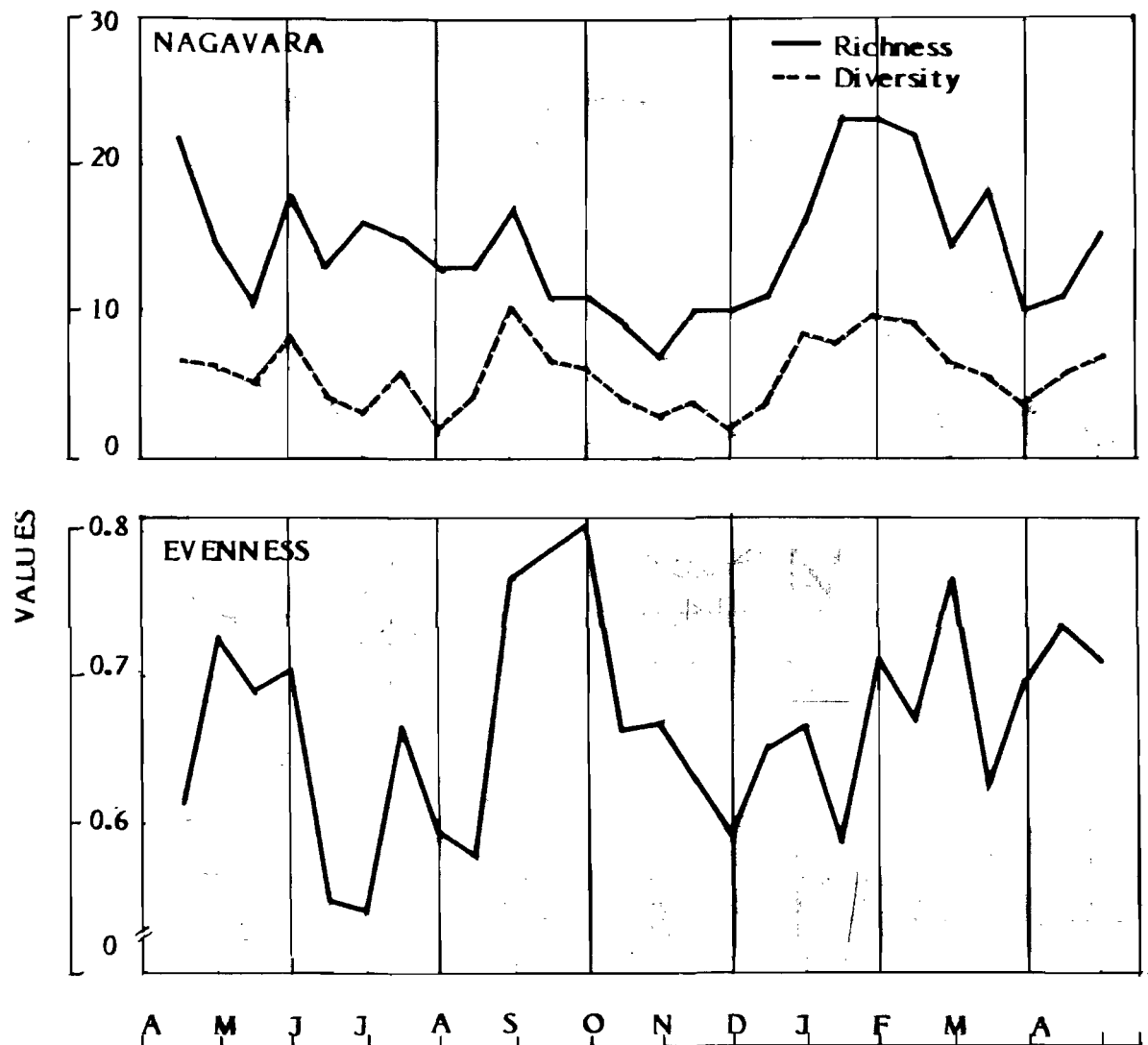


Fig. 13. Seasonal fluctuations in species richness, diversity and evenness at Nagavara area.

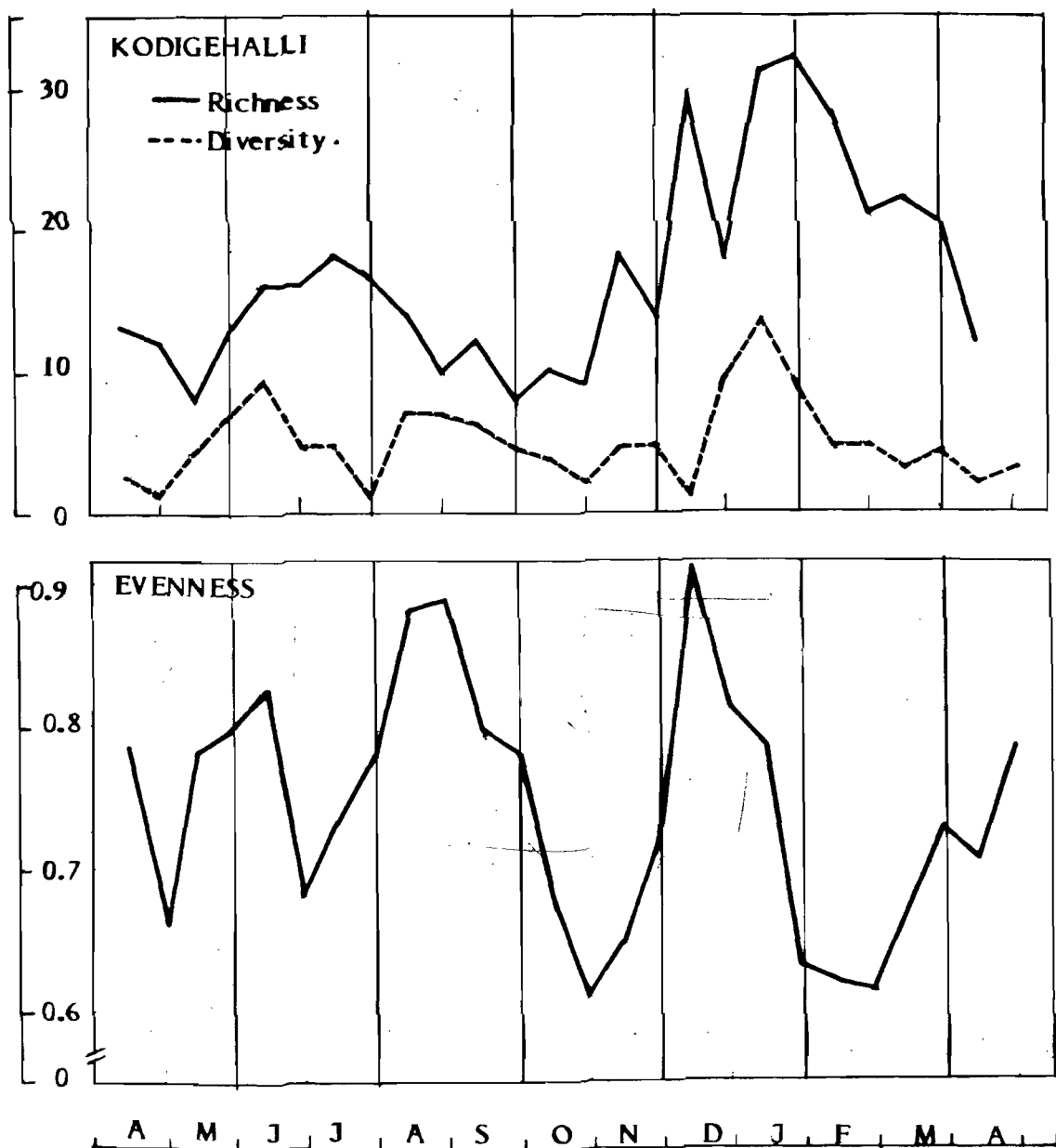


Fig. 14. Seasonal fluctuations in species richness, diversity and evenness at Kodigehalli area.

On a few occasions, whitebreasted waterhens (Plate 10) were seen feeding on grains from paddy earheads that were bent close to the bunds along the field edges close to hedge (at HBL). Their feeding activity inside standing rice crop could not be observed.

Blue rock pigeons foraged on fallen grains following harvest. In addition, at NGR pigeons, roseringed parakeets (Plate 15) and white-throated munias were seen feeding in harvested plots on grains spilled during harvest.

On a few occasions as observed at HBL, roseringed parakeets landed on top of the plant, cut and carried away the whole earhead of paddy on to the branch of a nearby tree. Parakeets fed only on a few grains from the earhead and discarded the rest.

In addition to feeding on standing crop and grains fallen on the ground after harvested plots, roseringed parakeets fed extensively in flocks as large as 143 individuals (as at NGR, Appendix V) in freshly seeded nurseries during June-August months at NGR and KGH. At HBL area they were seen observed feeding in nursery only once. Parakeets started to frequent the nurseries from the day of sowing till the seedling attained 2-3 cm in height. However, blue rock pigeons and whitethroated munias did not feed in nurseries.

Spotted doves and whiteheaded babblers usually fed on rice grains on the ground in plots close to tree line (as at HBL). Spotted

doves were also seen feeding on the ground on broad bunds at HBL.

The details of the food and feeding habits of baya and munias is dealt under section 4.6.2.

The secondary consumers included birds that fed insects pests of rice and several non-pest insects; several soil-invertebrates like crabs, spiders, nepids and earthworms (Appendix VI).

The insect feeders included streaked fantail warblers, Indian wren-warblers, pipits, wagtails, common and jungle mynas, cattle egrets, drongos and bee-eaters. Adult Baya and streaked weaverbirds did not feed on insects, but carried them to their nests to feed their young ones which depended only on animal matter.

The warblers, cattle egret, weaverbirds and often the common mynas gleaned insects from the foliage of standing rice crop. The streaked fantail and Indian wren warblers and weaverbirds fed in plots with standing paddy only after the crop reached late-tillering stage. Even though other warblers like ashy wren warbler, tailor bird, paddyfield warbler, blyth's and great reed warblers fed in fields similar to that taken by streaked fantail and Indian wren-warblers, no instances of actual feeding or food being carried in the beaks of these species was observed.

The food of streaked fantail warblers consisted of insects (95%) and spiders (4.28%) (Fig. 15A). The insect diet of this species

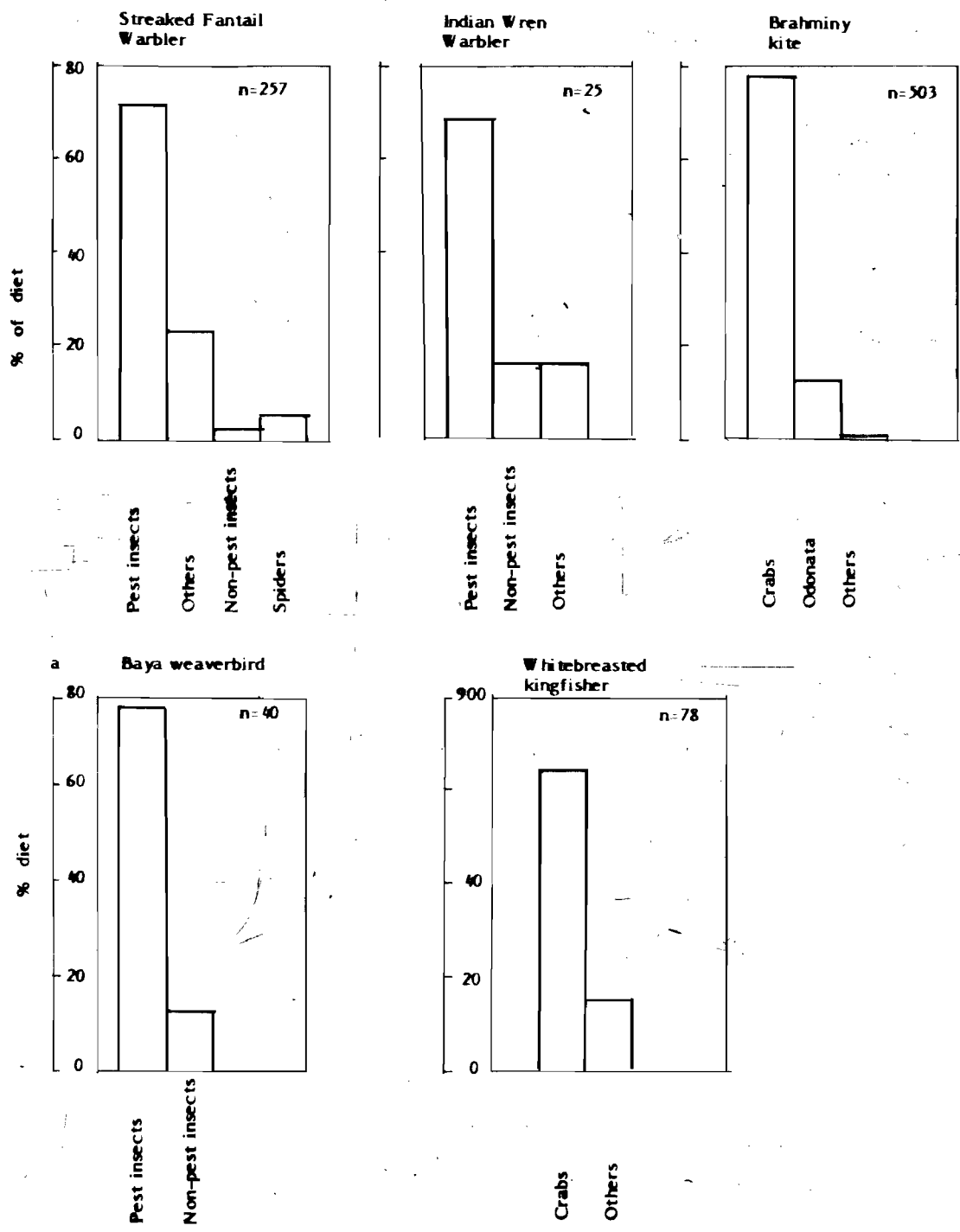


Fig. 15. Groupwise breakup of foods taken by birds in rice fields

included, grasshoppers (4.37%), paddy skipper larvae (54.76%), moths (1.98%) and low percentages of odonata, crickets, moths, paddy horned caterpillar, paddy leaf folder caterpillar, noctuid larvae, dipterans and spiders (Appendix - VI).

The food of Indian wren-warblers consisted of insects (68%) and spiders (16%) (Fig.15-B). Of these the paddy skipper larvae was the most common prey (48.15%), followed by grasshoppers (18.52%) and spiders (14.82%) (Appendix - VI).

Out of seven streaked weaverbirds observed at KGH only one individual fed on rice grains and five others were seen taking insects from the standing paddy.

Cattle egrets during their non-breeding season (after October) resorted to gleaning insects from standing rice crop. They entered the standing crop field and walked slowly between the rows of plants and hurriedly picked up the insects like grasshoppers and leaf hoppers that were flushed out and settled on adjacent plants due to disturbance caused by their own movement. The insects that were disturbed due to anyone moving through paddy include (*Oxya fascovittata*, *Tettigella spectra*, Distant, *Nephotettix* spp.). Other insectivorous ground foragers included pipits, common and jungle myna, wagtails (Appendix VI)

The food captured by pipits from dry fallow plots included grasshoppers, pyralid moths and wasps and were observed when the

nesting parent visited the nests to feed its young in the nest. Once a pied bush chat was seen at HBL landing next to a grasshopper on the ground and feeding on it later (Plate 21).

Grey and large pied wagtails frequented inundated fallow plots and inundated fields before tillering and after harvest. Greyheaded yellow wagtails could be seen in fields that were usually wet but not inundated before tillering stage and after harvest. In addition they were attracted to ploughing and harvesting operations. They were commonly seen resting on bunds of adjoining plots with standing paddy in winter. They readily entered and foraged among the base of the paddy plants whenever the plots were not inundated.

Common mynas were observed picking up insects from standing vegetation as they walked on the adjoining bund. Once a paddy horned caterpillar and a caterpillar feeding on *Jussia* were observed being taken by mynas. A mouse was taken once by a common myna at HBL.

Drongoes (Plate 19) and bee-eaters were aerial foragers and these birds sallied out from elevated perches like fence posts, overhanging tree-branches or electric wires or stakes to capture dragonflies in flight. Occasionally, pied bush chat, brown shrikes, and once a whitebreasted kingfisher were observed sallying and make unsuccessful attempts at capturing airborne insects.

The soil-invertebrate feeders included, pond horn, cattle and little egrets, plovers, sandpipers, snipes, stints, stilts and plovers.

Pond herons, egrets, brahminy kites (Plate - 22) brownheaded gulls, whitebreasted kingfishers, mynas and egrets showed a greater preference to feed on crabs (appendix VI).

Sandpipers, stints, stilts and snipes usually probed the wet mud or inundated soil with their long, slender pointed beaks. These birds were not seen feeding inside the field with standing crop after the tillering stage. The food of sandpipers, stints, stilts and snipes, taken by probing the soil could not be ascertained. However, once a common sandpiper was seen picking up noctuid caterpillars. On two occasions, spotted sandpipers were seen swallowing about 2-3 cm long dipteran larvae from freshly puddled plot.

Pond heron's food consisted mainly of crabs (88.89%) and very little insects (2.78%) (Appendix VI). While feeding pond herons walked slowly on the ground with its long forceps like beak held in front readily in wait. Sometimes, pond herons were seen standing motionless for 5-10 minutes with their beaks held ready to strike. Egrets also used these methods while feeding.

Pond herons showed considerably seasonality in crab capture and preferred only certain field conditions (Table 5).

They captured crabs from irrigation channels with shallow water during January and February when water was scarce at HBL (1983). Uncultivated inundated plots were available during March and August months for foraging. Pond herons were attracted to ploughing

Table 5. Utilization pattern of different rice field conditions for capturing crabs by pond hereon*

Field conditions	% Utilization												% Total crabs Taken
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	
Nala with shallow water	4.76	9.52											14.28
Uncultivated plot, inundated			9.52					4.76					19.04
Ploughing							14.29						14.29
Ploughed/puddled/levelled plot, inundated							4.76	19.04	4.76				33.33
Transplanted plot, inundated			4.76										4.76
Edge of plot with standing crop	9.52		4.76	4.76									14.28

n = 21 crabs

* Values in bold letters indicate Months and field conditions having high crab captures.

operations during July and they continued to forage in ploughed, puddled and levelled inundated plots from July to September and again frequented these field conditions in November and January. Transplanted plots were frequented during March when they fed along the edges of plots with standing crop during January and March to April months. Much of the crabs captured by pond herons were taken from ploughed, puddled and levelled fields (33.33%) followed by inundated plots (19.04%), shallow nala, plot edge and ploughings (14.28% each). Transplanted plots were least preferred (Table-5).

Cattle egrets captured crabs in only puddled inundated plot (3.03%) and during preparatory cultivations (96.97%), (Table-6).

Once an openbilled stork was sighted at KGH feeding on a crab in a ploughed, inundated field.

Little egrets captured crabs (thrice) during preparatory cultivations.

Other ground foragers that frequented field conditions before early tillering stage and after harvest were, little ringed plovers, golden plovers, redwattled and yellow-wattled lapwings and jacanas. These birds gleaned soil invertebrates from the surface of wet or inundated soil. The identity of the prey taken by these birds could not be ascertained.

Table 6. Utilization pattern of different rice field conditions for capturing crabs by cattle egret*

Field conditions	% Monthly captures												% total crabs taken
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	
Ploughing	30.20	24.24				27.27					6.06		96.97
Puddled plot, inundated	3.03												3.03

*n = 33 crabs

The tertiary consumers in rice fields included the whitebreasted kingfisher, house crow, common myna.

Much of the diet of whitebreasted kingfisher (Plate 16) comprised crabs (97.5%). Once it fed on a mice (**Mus musculus**) and on a young fledgeling of streaked fantail warbler (Fig. 15 C and Appendix VI).

During foraging, whitebreasted kingfishers were observed scanning the surrounding ground from elevated perches such as fence posts, overhanging branches electric wires, or wooden stakes stuck in the middle or along the edge of a field. On sighting prey it landed down, next to the prey, picked it up and either flew back to same or over to another perch closeby to feed on the prey.

The majority of captures of crabs made by whitebreasted kingfishers were from shallow irrigation nalas or from plots in which preparatory cultivation was carried out, plot edges and harvested fields (23.35%, 10.01%, 38.99% and 18.34% capture respectively). They were less frequently seen feeding in uncultivated, ploughed plot covered thickly with weeds or during preparatory cultivations (1.67% each) (Table-7).

Whitebreasted Kingfishers showed considerable seasonality in using different field conditions from which crabs were captured. The details of its seasonal crab capture is given in Table 7.

Table 7. Utilization pattern of different rice field conditions for capturing crabs by whitebreasted kingfisher*

Field conditions	% Monthly captures												% total crabs taken
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	
Nala with shallow water	1.67	3.33	1.67						1.67	11.67	1.67		23.35
Uncultivated plot, inundated											1.67		1.67
Ploughing						1.67							1.67
Ploughed/puddled/ levelled plot, inundated						1.67	1.67	1.67					10.01
Ploughed plot weedy, inundated						1.67	1.67						3.34
Transplanted plot, inundated								1.67					1.67
Edge of plot with standing crop	1.67			1.67					3.33	8.33	20.00	3.33	38.99
Harvested plot, inundated	3.33					1.67	3.33			1.67	8.33		18.34

* n = 60 crabs.

The food of house crows consisted of crabs (62.60%), earthworms (18.71%), mole crickets (11.38%) and others (less than 2.0%) were grasshopper, crickets, a moth and a plant bug. House crows were also seen once each feeding on a munia and a fledgling of a common myna (Appendix - VI).

Jungle Myna took spiders and mole crickets also during preparatory cultivation (Appendix - VI).

All the observed feeding instances of house crow and jungle mynas were during preparatory cultivations. Whenever a crow or a myna stopped to pick up a prey exposed by the plow, it was rapidly by-passed by other flock members who flew-over to position themselves behind the moving plough. As a consequence any bird after a few stops to pick up prey found itself behind an advancing flock. After feeding, from their position behind the moving flock, birds flew over the main body of the flock to be in front line of the flock right behind the moving plough.

Jungle crow and common mynas were also occasionally seen attending preparatory cultivations but in very low numbers.

During preparatory cultivations soil invertebrates such as crabs (*Oziotelphusa* sp.), mole crickets (*Gryllotalpa africana*) and earthworms (*Curgiana narayani* M.) were exposed along with the soil, due to the turning action of the plough (Table 8). The birds congregated during

Table 8. Variable abundance of soil invertebrates in unploughed and ploughed rice fields*

Soil invertebrates	Abundance per m ²	
	Unploughed plot	Ploughed plot
1. Molecrickets	-	2.10
2. Gryllids	-	1.50
3. Spiders	0.30	8.40
4. Odonata larvae	-	0.10
5. Coleoptera larvae	-	0.10
6. Carabidae	-	2.30
7. Stephylinidae	0.20	0.60
8. Earwig	-	0.50
9. Nepidae	-	0.10
10. Oxya fuscovittata	0.10	-
11. Earthworm	-	1.00
12. Crab	0.10	0.80

*n = 10 samples

P < 0.001 (Mann Whitney 'U' test)

these periods to feed on the exposed soil invertebrates (Plate 8). No sooner were they exposed, these soil invertebrates tended to hide by either moving into the puddle of muddy water or burrowing into the wet mud. As soon as the operation began, birds that were already present within the study areas were attracted to the plot being cultivated and in few minutes the birds from the surrounding area or adjoining fields started arriving at the spot. This response is presented in Fig. 16, 17, and 18. The birds usually showed a monotone increase in their numbers as long as the operation continued. Their number rapidly decreased immediately after the operation stopped. If the operation resumed after a brief halt the birds were again attracted.

Little and cattle egrets were also attracted to plots under preparatory cutlivations, but, their feeding method differed from that of crows and mynas. Instead of flying overhead, like crows and mynas, they walked briskly or ran to occupy the front ranks of the moving body of egrets to position themselves behind the moving plough.

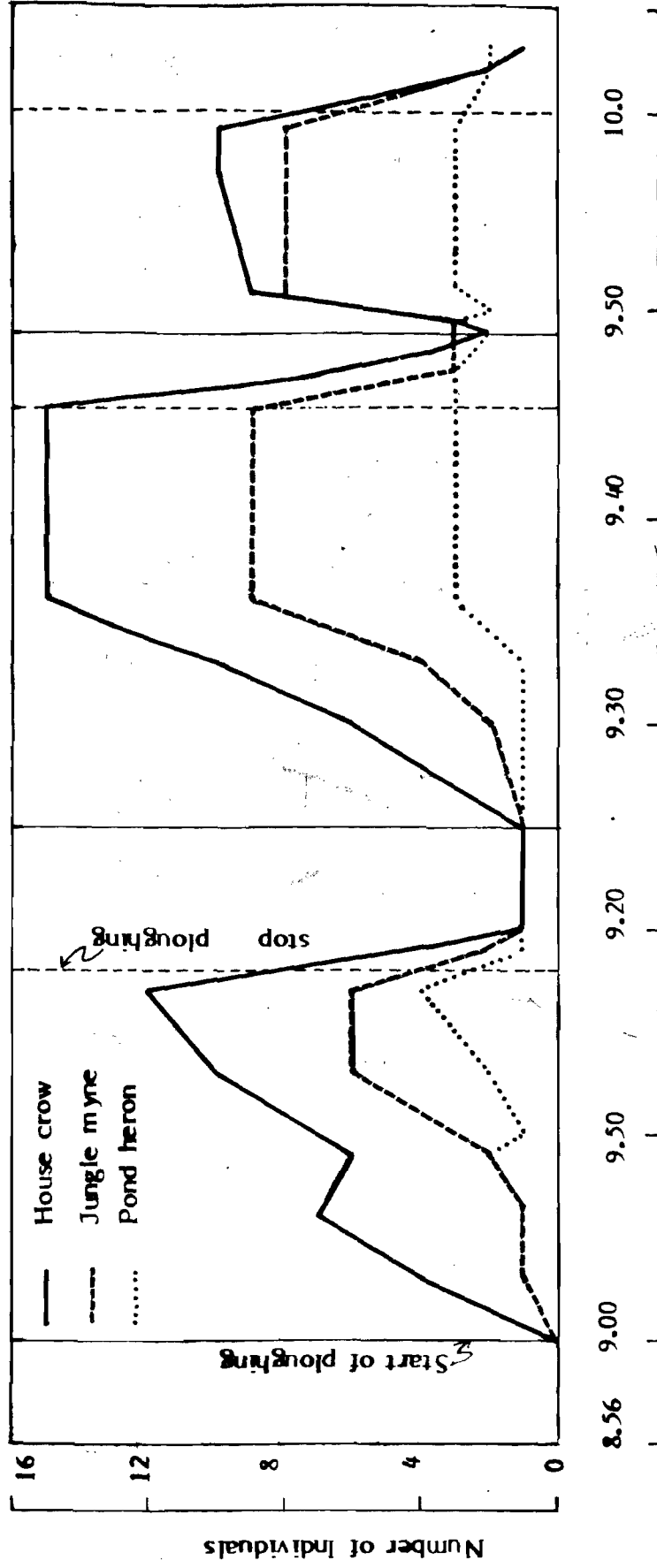
Ploughing sessions were highly preferred by house crows and 71.78% of total crab captures was made during June-August and November to December. While puddling and levelling operations were less preferred (1.38%). They captured 6.92 per cent of total crabs from ploughed inundated plots (during February, March, June and November (Table 9). House crows were attracted to plots being harvested during early winter to feed on crabs (19.44%) (Table 9).

Table 9. Utilization pattern of different rice field conditions for capturing crabs by house crows*

Field conditions	% Monthly captures												% total crabs taken
	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	
Ploughing	16.67					9.72	6.49	16.67	5.56	16.67			71.78
Puddling/levelling		1.38											1.38
Ploughed plot, inundated		1.38	1.38						2.78				6.92
Harvesting										19.44			19.44

* n = 72 captures.

Fig. 16. Response of birds to ploughing in rice fields



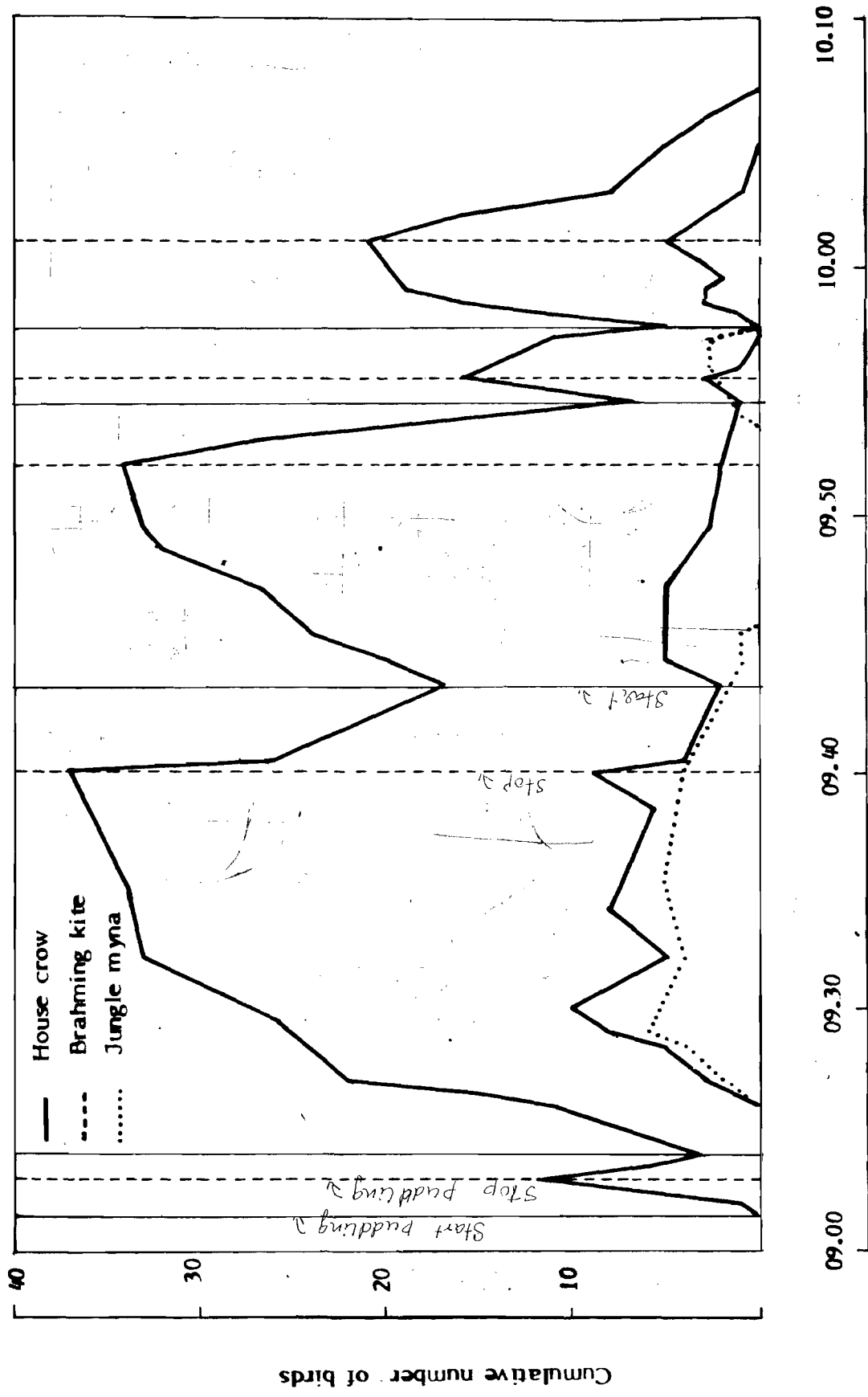


Fig. 17. Response of birds to puddling in rice fields.

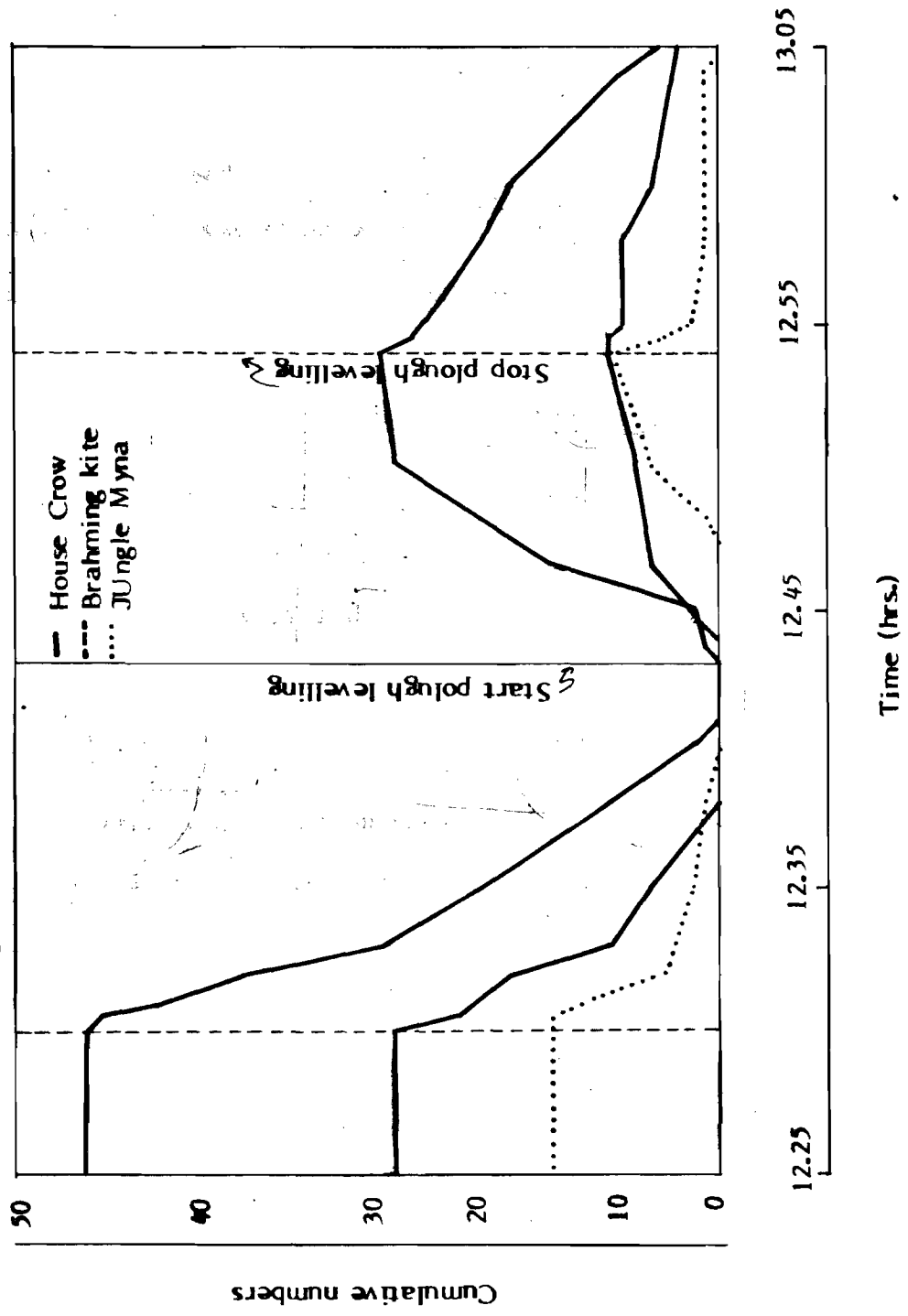


Fig. 18. Response of birds to levelling in rice fields

On these occasions rarely was any fight observed between flock members. The number of pond herons, common myna and jungle crows were always low whereas, House crows, little and cattle egrets and jungle mynas were high (Fig. 16, 17, 18).

Crows and mynas were abundant during ploughing and puddling, but very few of these could be seen during the latter part of levelling operations. Egrets were rarely encountered during harvesting. During the harvesting of kharif crop migrant greyheaded yellow wagtails were attracted.

Harvesting elicited a response similar to that of preparatory cultivation. The pattern of build up of bird numbers is presented in Fig. 19. Crows, mynas and wagtails move among the cut stubbles to feed on the insects disturbed when the crop is cut. Crows also feed on the crabs that were once hiding under the standing crop.

During winter, brownheaded gulls frequented Hebbal and Nagaravara Tanks. Few of the gulls strayed into HBL and NGR during January-February. At HBL area one bird frequented a plot being puddled and captured three crabs by wading in the plot. At NGR area of the six crabs taken by the gulls, two were from uncultivated, inundated plots, while the rest were from ploughed plot. At NGR area brownheaded gulls hawked on the crab from air after flying over the area.

Brahminy kite's diet comprised crabs (93.96%), and dragonflies (5.52%). They were also seen taking a snake, a rat and a ruddy

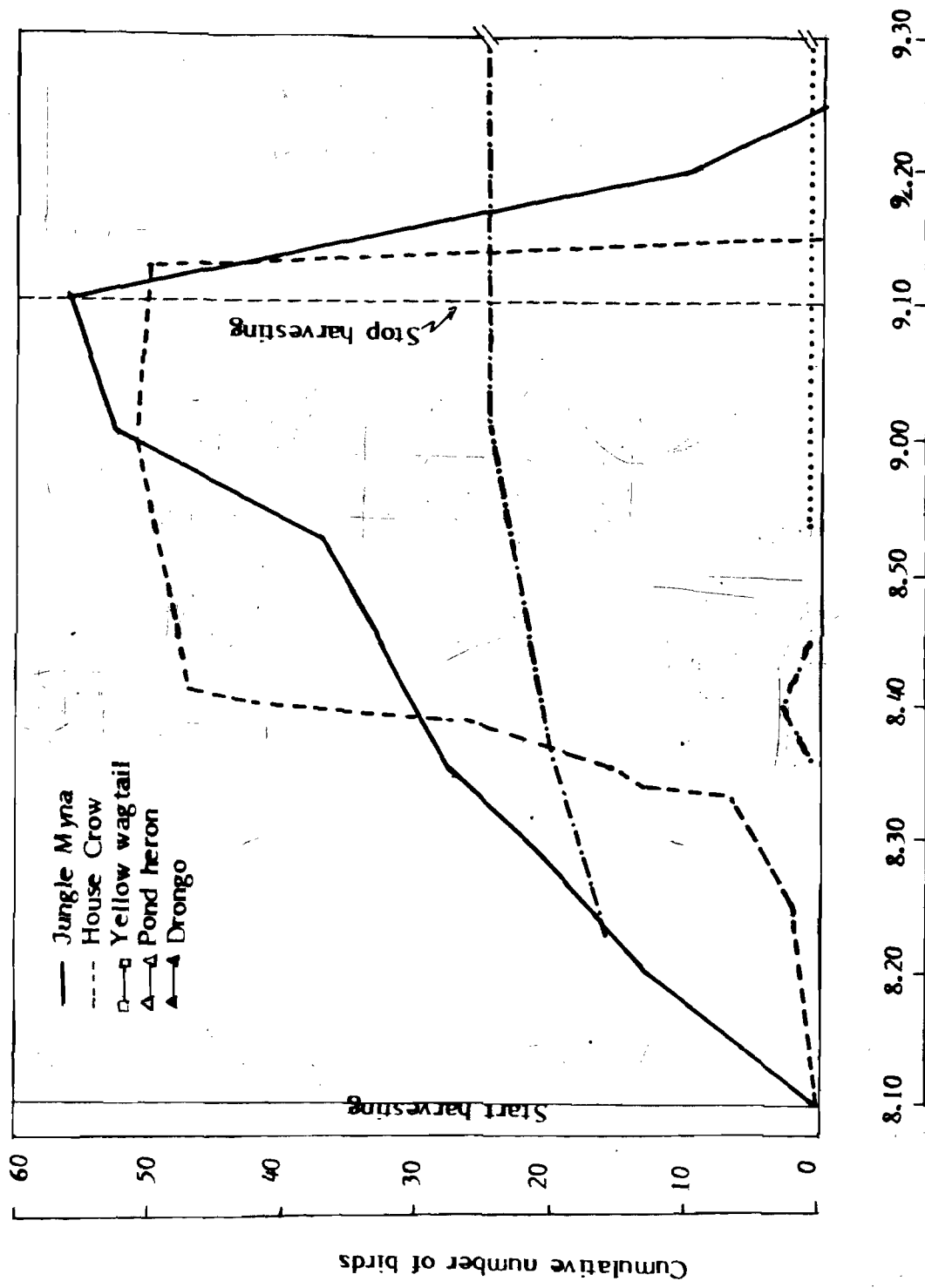


Fig. 19. Response of birds to harvesting of paddy



Plate 21 : Pied Bush Chat, an irregular resident, feeds on insects.



Plate 22 : Empty Crab carapaces discarded by brahminy kites, on one of their feeding sites - Hebbal area

crake which comprised less than one per cent of the kites' diet (Appendix VI and Fig. 15, D). Brahminy kites captured crabs in two ways, one by slowly flying over the open fields and picking up the crabs sighted by swooping and another method was by swooping down on prey along the edges of plots with standing crop, from a suitable perch. The latter method was used when the entire area was covered with paddy.

As per the observed feeding records, Brahminy kites took a heavy toll of crabs during harvesting (39.63%) and during preparatory cultivations (33.39%) (Table-10). The rest were taken from uncultivated plot (0.73%) ploughed, puddled and levelled plots (12.28%), transplanted plots (2.87%), plot edges (4.76%), harvested plot (3.67%) and harvested plots covered with sprouted stubbles and weeds (2.57%) (Table 10). Monthwise breakup of crab captures in different field conditions is presented in Table 10.

The number of crabs predated by brahminy kites as indicated by the empty carapace (Plate 22) counts is presented in Fig.20. The crab capture by brahminy kites at HBL showed two peak in August-September and December-February coinciding with preparatory cultivations during the latter period. At NGR crab feeding by kites was highest from December 1983-March 1984 period than July-September 1983 preparatory cultivations. At KGH crab feeding was intense during May 1983 and another crab feeding peak was observed during December, February-March 1984. However, among the three areas large number of carapaces was collected at NGR, followed by HBL and KGH.

Table 10. Utilization pattern of different rice field conditions for capturing crabs by brahminy kites*

Field conditions	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	% total crabs taken
Uncultivated plot, inundated						0.55						0.18	0.73
Ploughing/puddling/level-ling	1.10					0.18	15.05	13.95				4.04	33.96
Ploughed/puddled/levelled plot, inundated	6.23	1.47	0.55			0.18		2.57	0.55			0.73	12.28
Transplanted plot, inundated		0.37						1.40	0.73	0.37			2.87
Edge of plot with standing crop			0.18	0.18				0.18		0.37	3.67	0.18	4.76
Harvesting				0.18							31.38	8.07	39.63
Harvested plot, inundated			0.37									3.30	3.67
Harvested plot, weedy/sprouted stubbles, inundated	0.18							0.37	0.18		0.92	1.10	2.57

* n = 545 crabs

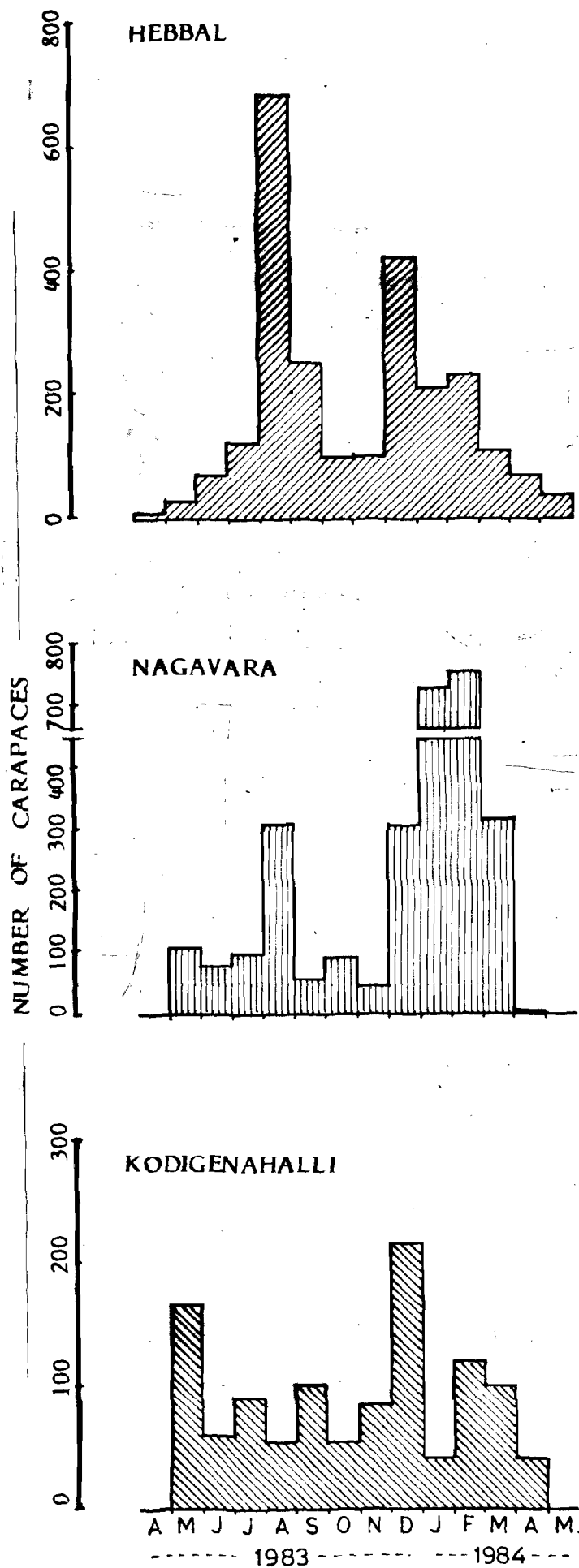


Fig. 20. Monthly counts of empty crab carapaces collected at different study areas.

In addition to feeding on crabs and other vertebrates, brahminy kites were observed feeding on dragonflies during early mornings before 9.00 AM and during evenings from 5.00 PM onwards. Kites were observed feeding on dragon flies on 32 instances spread over 22 days spanning over six months (September-December 1983, February and April 1984). The details of seasonal captures is presented in Fig. 21. The Kites', peak activity was during late rainy months and early winter months. Brahminy kite's fed on dragonflies in addition to crabs during these months. Dragonflies were captured in less numbers during February and April 1984 (Fig. 21).

Dragonflies were found to have the habit of resting at the earhead level during evenings (after 4.30 PM) and remained in the same place till about 9.00 AM next morning. Upon inspection during subsequent hours of morning the odonation's wings were wet (Plate 23) and the dragonflies made no attempt to fly, probably because of the heaviness of the wet wings. They usually took to flight only after their wings dried. Only the plots with standing crop after late tillering was used by ddragonflies for resting.

To capture dragonflies, the brahminy kites flew slowly low over the cropped area and suddenly swooped down from air with a twist of wings to pick up the insect with their talons. The insects were transferred to the beak and eaten while in flight.

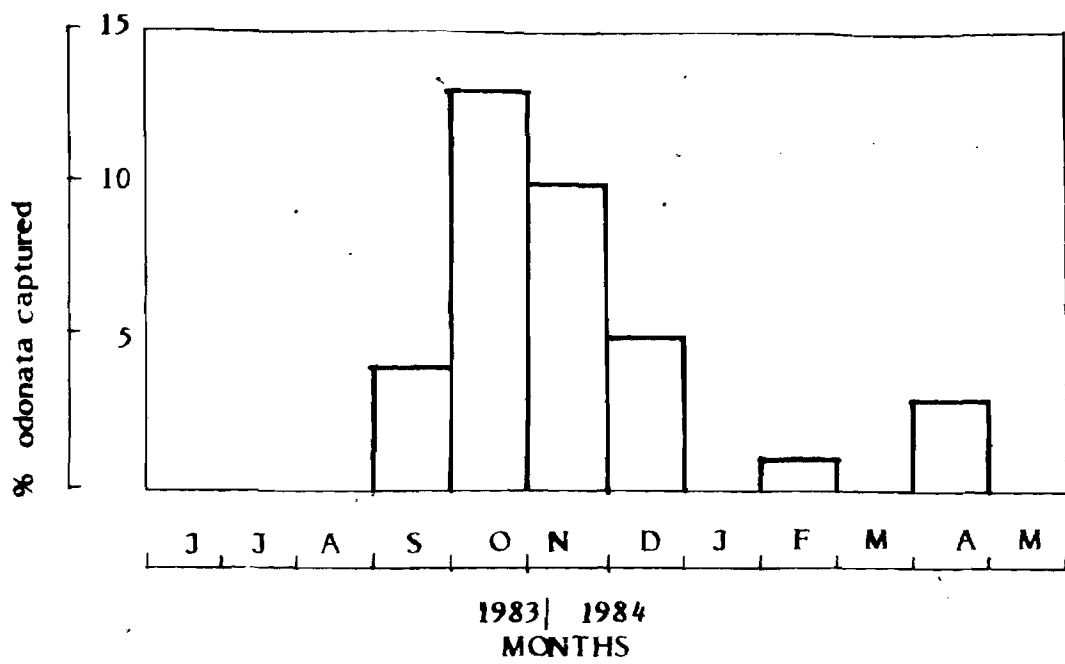


Fig. 21. Seasonal feeding activity of brahminy kites on odonata.



Plate 23 : A dragonfly resting on rice earhead. Wings are wet due to overnight mist.



Plate 24 : Spotted owlet, a nocturnal Carnivore in rice fields.

House crows were seen unsuccessfully attacking an adult and an young baya weaverbirds during the latter's nesting season during monsoon. On another two instances house crows were observed feeding on a munia (*Lonchura* sp.) and a live fledgling of a common myna, at HBL.

Spotted owlets (Plate - 24) were active after dusk, hawking on insects flying close to the paddy crop canopy level. A pellet of the owlet collected beneath its nest-burrow on a mango tree adjacent to HBL, revealed a complete skull of a mice (*Mus* sp.).

The top carnivores included three birds of prey, namely the brahminy kite, marsh harrier and the redheaded merlin (a falcon) (Plate.25)

Brahminy kites were seen feeding on vertebrates on three instances. A bandicoot (HBL) *Bandicoota benghalensis*, a snake from a ploughed plot at NGR and a ruddy crake that was running on the grass covered path to cross over to an adjacent farmer's field at HBL. Once a brahminy kite was seen unsuccessfully swooping on a streaked fantail warbler perched on a paddy earhead at KGH (Appendix VI).

Marsh harriers were seen feeding on a green sandpiper, a bandicoot (*B. benghalensis*) (HBL), a little egret (Plate 26) and a bluewinged teal (*Anas querquedula*), both at NGR area and a snake at KGH (Appendix - VI). Marsh harriers were invariably seen coursing low over the cropped fields on almost motionless wings in a long sailing

flight. Instead of swooping on the prey, they dropped down on the prey. The prey was consumed on the ground, usually on bunds separating two adjacent fields with standing crop.

Redheaded merlins were observed feeding only on small birds like baya on two occasions one each (HBL and KGH), an indian pipit (HBL); and an indian wren-warbler (HBL). In addition these falcons were seen unsuccessfully attacking jungle mynas (twice); a whitebreasted kingfisher, a green sandpiper, a spotted munia (all at HBL) and a streaked fantail warbler at KGH.

The merlins usually flew very low in the air, about a foot or two above the crop canopy level at great speed and seized away any bird perched on earhead or airborne. The prey was grasped with talons as the merlin shot past above it. At HBL, a baya and an indian wren warblers, both of which perched singly on rice earheads were snatched by the merlins using this method. At KGH another baya in flight was captured by a merlin.

Apart from these three top carnivores, a shikra was once seen swooping on a streaked fantail warbler perched on a paddy earhead in a plot close to the tree line. The fantail warbler escaped. At NGR area a brown shrike was seen capturing a small frog from a shallow irrigation nala. The shrike flew down from an overhanging branch of *Pithecellobium* bush to landed close to the frog. On capturing the frog the shrike flew over to a bush and impaled the frog on an uneven cut-end of a branch. *The frog was eaten after half an hour.*

Pale harriers and blackwinged kites were observed foraging in the study areas; the latter only at HBL, but no prey captures were made by either of them.

An avian food web constructed based on the direct field observation on birds' prey capture and feeding is presented in Fig. 22.

The prey capture or food items taken by species other than those dealt in this section was not recorded.

Of the nine species of birds observed feeding on crabs from 776 instances brahminy kites were most frequently sighted (70.32%) feeding on crabs, followed by house crows (9.94%), whitebreasted kingfishers (9.81%), cattle egrets (4.26%), pond herons (4.13%), brownheaded gull (11.03%), little egret (0.38%), jungle crow (0.13%) and open billed stork (0.13%) (Fig. 23).

There was considerable differences in the crabs preyed upon by some of the birds. Whitebreasted kingfisher, and pond herons, preferred smaller crabs than brahminy kites. Few of the crabs taken by pond herons had soften carapace. Pond herons and egrets after capturing the crab, manipulated it between their beaks and by crushing the crab several times, made it pulpy before being swallowed. Whitebreasted kingfishers on the other hand, flew with the crab on to a perch and battered it on the perch repeatedly till all or most of its appendages were broken and removed and only the body of the crab devoid of most of its appendages was swallowed whole. Brahminy kites prepared the prey a great deal before feeding. They flew with

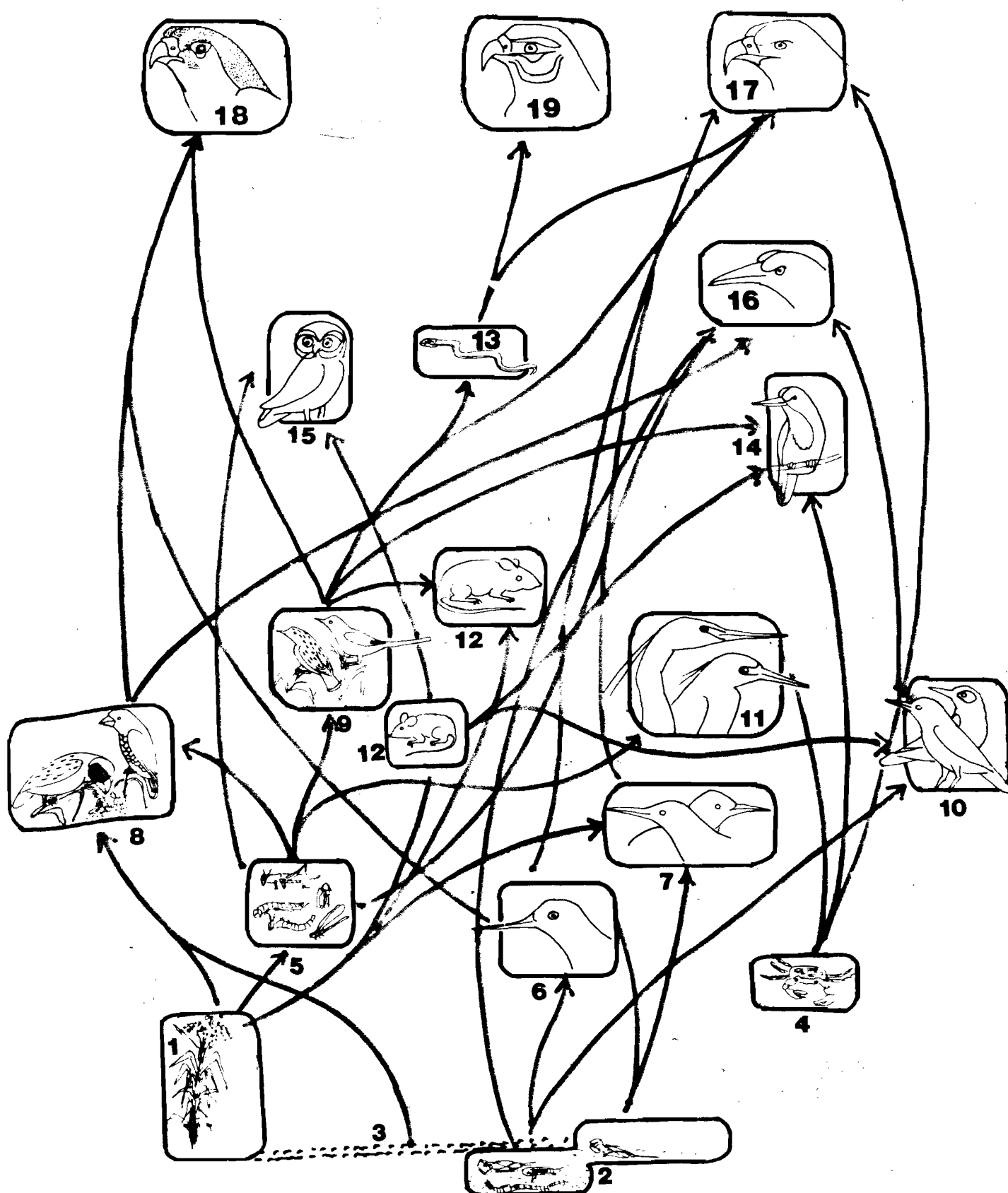


Fig. 22. AN AVIAN FOOD WEB IN RICE FIELDS

1. Rice crop	2. Soil invertebrates	3. Spirogyra	4. Crabs
5. Insects	6. Plovers & sandpipers	7. Rails	8. Bayas and munias
9. Insectivorous warblers	10. Mynas	11. Egrets	12. Rodents
13. Snakes	14. Whitebreasted kingfisher	15. Spotted owl	16. Crows
17. Brahminy kite	18. Redheaded merlin	19. Marsh harrier	

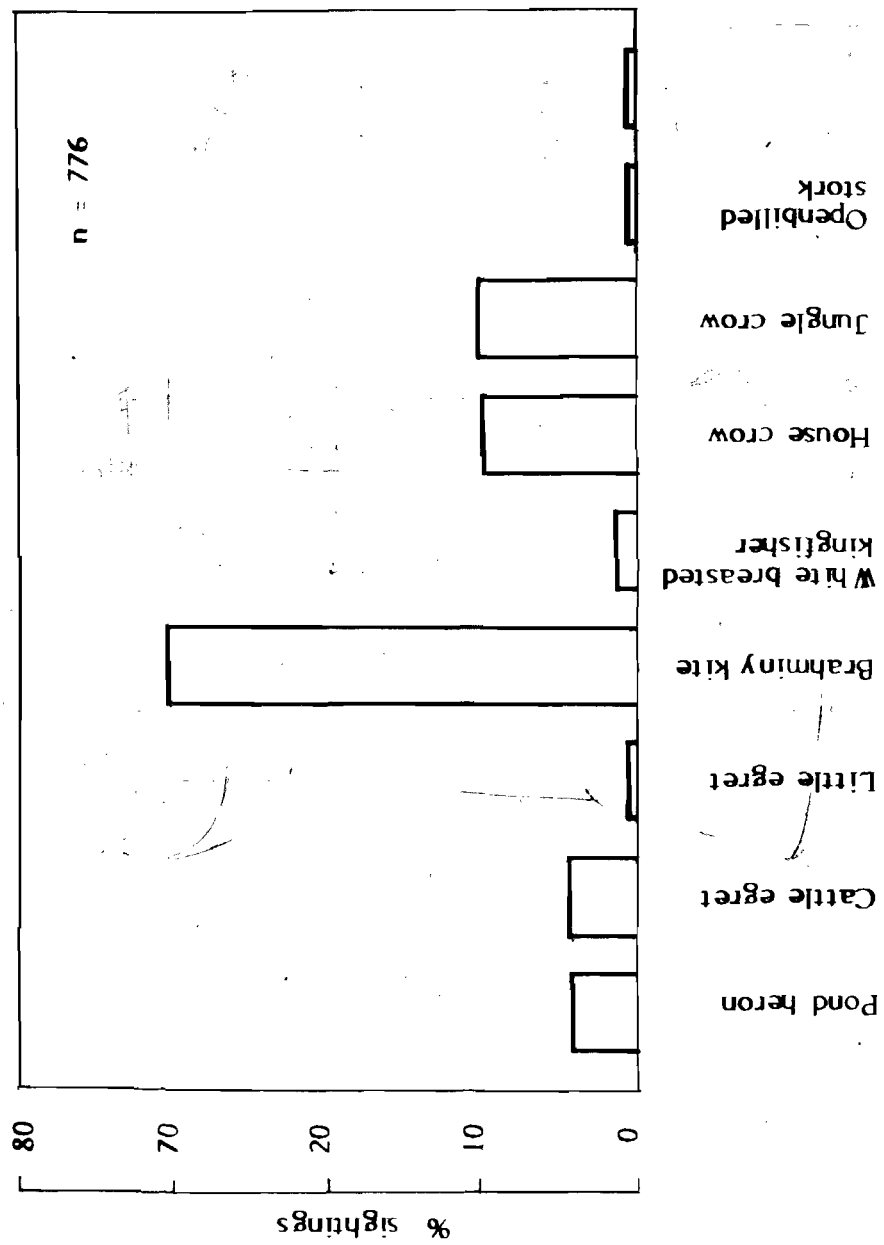


Fig. 23. Relative intensity of feeding on crabs by certain birds in paddy fields.

the crab on to a fence post or an overhanging electric wire or a tree, or on to the raised section of a bund. There, with the prey held firmly between its talons and legs were removed first. After this the crabs abdominal flap was ripped apart and the inner contents were scooped by their hooked beaks and devoured. The empty, uneaten, carapace was discarded later. As a result at the place or at the base of the perch where the kites fed on the crabs, the discarded empty carapaces could be seen (Plate - 23). Crows swallowed the crabs whole if they were small after crushing them few times or if the crabs were larger removed the legs, split open the body to feed on the contents. The gulls swallowed the crabs whole.

Table 11 summarizes these foraging methods, nature of prey, mode of feeding, foraging field types and shift in feeding sites, approximate prey size of crab feeding birds.

Pooling the seasonal crab capture pattern of all the species would also show the seasonal availability of different field type and successional trend in habitat utilization by crab feeding birds (Table 12).

4.6.2 Activity pattern of certain bird pests of rice

Sparrows, weaverbirds and munias gleaned grains directly from the paddy earheads from milking to ripened stage of the crop.

Table 11. Summarized feeding pattern of crab feeding bird§

	Foraging method					Type of the crabs preferred			Mode of feeding		Plots types usually frequented before the shift in foraging site occurred				Period when shift occurred	Site of feeding before the shift occur -red	Site of feeding after the shift occur -red			
	Coursing and still hunting	Perch - to - site	Walk and strike	Ground gleaning	Plough fallowing	Young soft bodied	Medium sized	Large with hard carapace	Tear and scoop	Batter & swallow	Swallow, whole	Uncultivated plot, inundated	Ploughing	Puddling				Levelling	Ploughed/Puddled, levelled inundated plot	Transplanted plot
Brahminy Kite	+							+	+			+	+	+	+	+	+	Late tillering stage of crop	Inside the plot	Plot edges
Pond Heron		+				+				+	+	+	+				+	Late tillering stage of crop	Inside the plot	Plot edges
House Crow					+	+	+	+	+	+	+		+	+	+			Puddling and levelling	Inside the plot	Bunds
Jungle Crow					+	+	+	+	+	+	+		+	+	+			Puddling and levelling	Inside the plot	Bunds
Whitebreasted Kingfisher		+				+	+		+	+	+	+	+				+	Late tillering stage of crop	inside the plot	Plot edges
Little Egret			+		+	+	+				+	+	+	+	+		+	-	Inside the plot	-
Cattle Egret			+		+	+	+				+	+	+	+	+		+	-	Inside the plot	-
Brownheaded Gull	+			+				+	+	+		+	+	+	+		+	-	-	-

Table 12. Pooled seasonal crab capture and rice field utilization by crab feeding birds*

Field conditions	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.	% total crabs taken
Nala with shallow water	0.28	0.55	0.14	0.14	0.14				0.14		0.97	0.14	2.36
Uncultivated plot, inundated	0.14		0.28			0.42		0.14				0.28	1.25
Ploughing/puddling/levelling	2.49	0.14				1.94	14.68	12.19			0.69	4.57	36.70
Ploughed/puddled/levelled plot, inundated	5.12	0.42	0.14	0.14		0.42	1.25	3.05			0.42	0.69	12.05
Transplanted plot, inundated		0.28	0.14	0.14				1.25	0.55	0.28			2.63
Edge of plot with standing crop	0.42		0.14	0.28			0.14	0.14	0.24	0.97	4.43	0.42	7.20
Harvesting								0.14			23.68	8.03	31.72
Harvested, inundated	0.28		0.28			0.14	0.28					3.19	4.16
Cut, weedy and stubbles sprouted, inundated	0.14				0.55		0.14	0.28	0.14			0.69	1.94

* n = 722



Plate 25 : Brahminy Kite, a major predator of crabs in rice fields.



Plate 26 : Dismembered remains of a Little Egret killed and eaten by Marsh Harrier at Nagavara.

These birds perched directly on top of the paddy plants and fed on the grains. They picked individual grains from the earheads.

Among several species gleaning grain from earheads, weaverbirds and munias were the most common. Streaked weaverbirds were observed only at KGH during April 1984. Of the seven individuals sighted, only one was seen feeding on paddy grains while the rest were seen picking up insects that were eventually carried towards their nesting colony.

Besides feeding on paddy grains, four species of munias namely, whitebacked, whitethroated, spotted and blackheaded munias were observed feeding on filamentous green algae (*Spirogyra* sp.) grown in patches during October-December of 1982 at HBL.

Outside the study areas, Munias and bayas were seen feeding on the grains of *Panicum maximum* and other fodder grasses grown abundantly at the University of Agricultural Sciences, Hebbal Campus, and in the nearby Military Dairy farm (Fig. 1). The grains of these grasses put out new shoots or grew from fallen seeds with the onset of monsoon. The luxuriant growth of these grasses showed another peak with north-east monsoon, and set seeds by November-December. Munias and bayas fed extensively on these grasses in small flocks of less than 10-50 birds. Most of the munias perched directly on the earheads of these grasses to feed on the grains, while red munias foraged on the grains fallen on the ground. These fodder grasses had an early

shedding habit and munias could be seen feeding on grains fallen on the ground close to the base of the grass clumps. During monsoon periods munias were also seen feeding on mature **Cynodon dactylon** patches.

Often at the Main Research Station of the University of Agricultural Sciences and regularly at the Military Dairy farm, fodder jowar and bajra were grown in small areas during monsoon and these crops came to maturity during September-October. Bayas and spotted munias formed large flocks upto 350 birds and fed on the matured grains of jowar and bajra.

Bayas and munias excluding the red munias, showed two peak feeding periods at the study areas. Mainly from early morning from the time of their arrival till about 9.30 A.M. and again during the afternoon from about 3.30 to dusk, i.e. the time till they departed to their roost site. The non-feeding hours within the study areas were spent in the canopy of the tree line or sunflower whenever the standing crop was available or in the dense stand of sugarcane crop grown at HBL area during 1982-83.

In case of red munias, the feeding activity periods could not be recorded as they used to seek refuge among the standing plants of paddy crop.

At HBL area bayas and munias were observed feeding on rice from July till mid September 1982, mid March to end of August

1983 and again, in February, April to July 1984. In KGH area it was from April to July-August 1983 and December 1983-January and March 1984, while at NGR the feeding on paddy was observed from April-June of 1983 and again from October-November 1983 and January-February of 1984 (Fig. 8, 9, 10)

The bayas and munias with the exception of red munias, always foraged very close to the vegetation cover in all the three study areas. At HBL area, whenever the birds feeding on paddy were flushed, they flew back into the thick canopy of the tree line closeby or into the thick stand of sugarcane or sunflower that were grown in small patches. Red munias showed a tendency to form pure flocks, and feed within the cover of standing mature paddy. They were extremely difficult to spot even at a close range of a metre. But once flushed, they flew straight up and circled over the cropped area in a tight flock uttering a very audible 'ji-iv' notes. Later they dropped back to conceal among the standing paddy. At NGR munias flew into the cover of the bush of *Pithecellobium* while sparrows and bayas flew over to sit on overhanging electric wires that passed over the study area. Red munias when disturbed either flew out of the study area when disturbed or settled among the standing paddy after circling over-head for a few minutes. At KGH area, with the exception of Red munias that flew out of the study area, all other bird pests (Munias and bayas) flew into the treeline when disturbed.

Out of 25 census made over four months, 76.53 per cent of the sightings of the mixed feeding flocks of munias and bayas (exception red munias) foraged within 10 metres from the cover ($r = 0.837$, $P < 0.001$). These birds were less frequently seen foraging farther away from the vegetation (Fig. 24).

Red munias were never seen sharing the cover of tree canopy, sugarcane or sunflower crop stands, with either bayas or other munias. Instead the whole flock used the mature stand of paddy itself as cover. In these stand of paddy they foraged very close to the ground and fed on grains from earheads bent close towards the ground. They were never seen feeding at the canopy level of the crop. They were also seen perched close to the earheads of tillers that bent close to the bunds separating two adjacent plots with mature crop of paddy. In these positions they fed on the grain.

Further, it was found that the number of bird pests (the total number of birds comprising all the individuals of each species of munias and bayas) at HBL area did not increase, positively with the increase in the are of mature crop available for feeding (Fig. 25). A low correlation ($r = 0.083$; $P < 0.001$) existed between the bird numbers and the amount of mature crop available for their feeding, during summer periods when their populations were abundant.

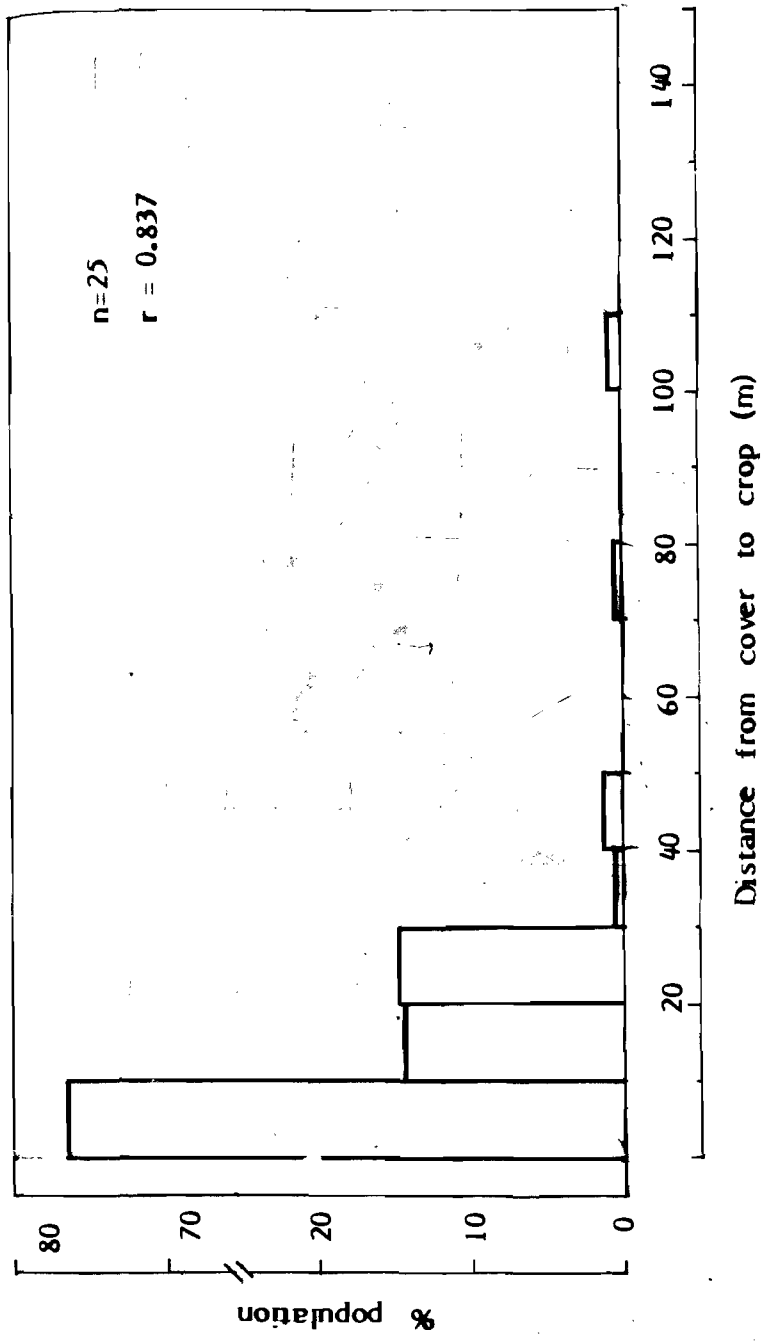


Fig. 24. Feeding concentrations of bird pests of rice at different distances from cover.

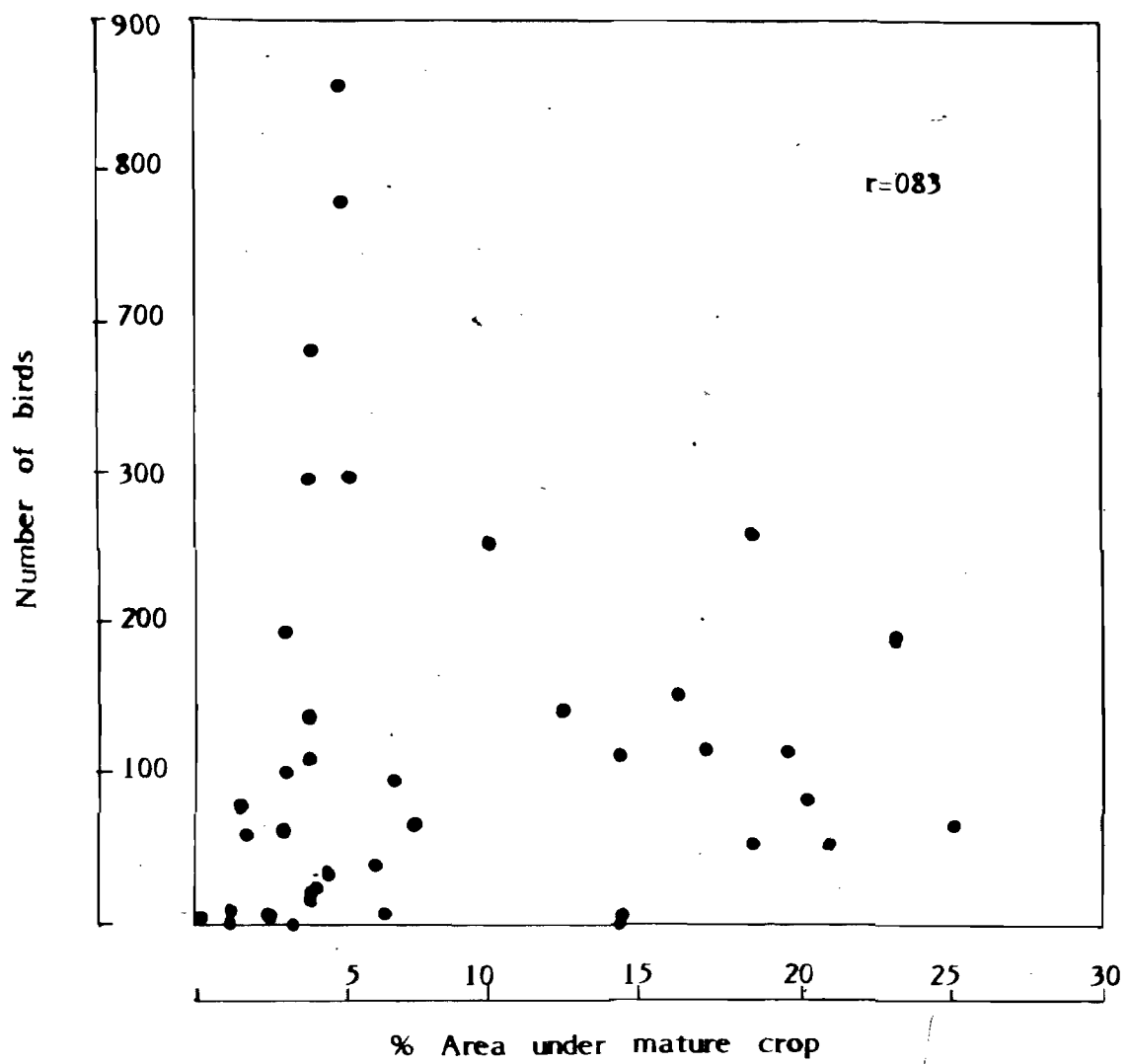


Fig. 25 : Relationship between the number of bird pests and the area under mature rice crop at Hebbal area.

On a few occasions bayas and munias were observed feeding on barnyard millet (*Echinochloa* sp.) earheads (upto 10 plant/0.045 ha). The experiment laid out in 1983 at HBL in an area of 0.06 ha, it was seen that the bayas and munias readily responded to the availability of *Echinochloa colonum* and their entire population switched over from feeding on paddy to *Echinochloa*. As the supply of *Echinochloa* decreased due to bird feeding and early grain shedding, nature of the millet, the number of birds feeding on them also decreased and when the grains of *Echinochloa* were totally depleted, the birds reverted back to paddy (Fig. 26).

The experiment carried out during November 1983-February 1984, to study the feeding response of bayas and munias to seven varieties of paddy, revealed that Doddabyra, Jenugudu and Ct-1351 were severely damaged, (95.31-100%); IR-36, IR-42 and IR-48 suffered low damage (0.85-14.94%), and Pragathi was not visited by birds at all (Table 13). Correlation analysis among different plant characters (independent variables) and the damage (dependent variable) (Table-13) showed that the extent of damage was highly correlated with the earhead type, angle of the flagleaf, and the projection of the flagleaf above the earhead ($r=0.8501$, 0.6917 and -0.6686 , respectively; Table 14). The characters that influenced damage moderately but significantly, were the plant height, spread of the plant and the length of the flagleaf ($r=0.4450$, 0.4465 and 0.4245 , respectively; Table - 14).

Apart from this, the angle of the flagleaf was negatively correlated with earhead type ($r=-0.6175$) and positively associated with projection of the flagleaf ($r=0.5467$). Also, the earhead type had

Table 13. Differences in Plant characters in different rice varieties associated with extent of damage.

Sl. No.	Varieties	Plant height (cm)	Angle of flag leaf (degrees)	Projection of flag leaf over earhead (cm)	Earhead Type	Plant spread (cm)	Damaged earheads (%)
1.	CT-1351	107.08 ± 8.41*	68.40 ± 4.17	6.76 ± 7.79	Erect	24.50 ± 6.97	97.31 ± 6.71
2.	Doddabyra	112.35 ± 8.52	56.14 ± 9.99	10.20 ± 9.20	Semierect	23.82 ± 3.35	100.00
3.	IR-36	59.58 ± 7.13	79.64 ± 6.73	13.24 ± 3.72	Drooping to semierect	23.36 ± 6.30	14.94 ± 20.47
4.	IR-42	52.84 ± 2.63	77.27 ± 4.97	15.70 ± 3.79	Drooping	21.18 ± 3.95	2.18 ± 3.52
5.	IR-48	59.66 ± 2.94	88.75 ± 2.45	15.81 ± 2.47	Drooping	9.14 ± 0.99	0.85 ± 2.76
6.	Jenugudu	94.22 ± 9.62	76.09 ± 8.13	0.33 ± 4.69	Erect	19.14 ± 4.05	100.00
7.	Pragathi	58.29 ± 4.12	89.80 ± 0.28	21.03 ± 5.13	Drooping	11.50 ± 3.79	0.00

* Standard deviations.

Table 14. Matrix of correlation coefficients *indicating the associations between different plant characters of rice and damage by bird pests.

Variables	LFL	AFL	EHT	PFL	SPT	PDE
PHT	0.1017*	-0.1401*	0.2066*	-0.1981*	-0.0152*	0.4456
LFL		-0.4230	0.4205	-0.1371*	0.1580*	0.4242
AFL			-0.6175	0.5467	-0.5789	0.6917
EHT				0.7608	0.3482*	-0.8501
PFL					-0.2403*	-0.6686
SPT						0.4465

Variables	PHT	:	Plant height,
	LFL	:	Length of flag leaf,
	AFL	:	Angle of flag leaf,
	EHT	:	Earhead type,
	PFL	:	Projection of flagleaf above the earhead,
	SPT	:	Spread of the plat,
	PDE	:	Per cent damaged earhead,
	*	:	Non significant

All unmarked values are significant at P < 0.001 level.

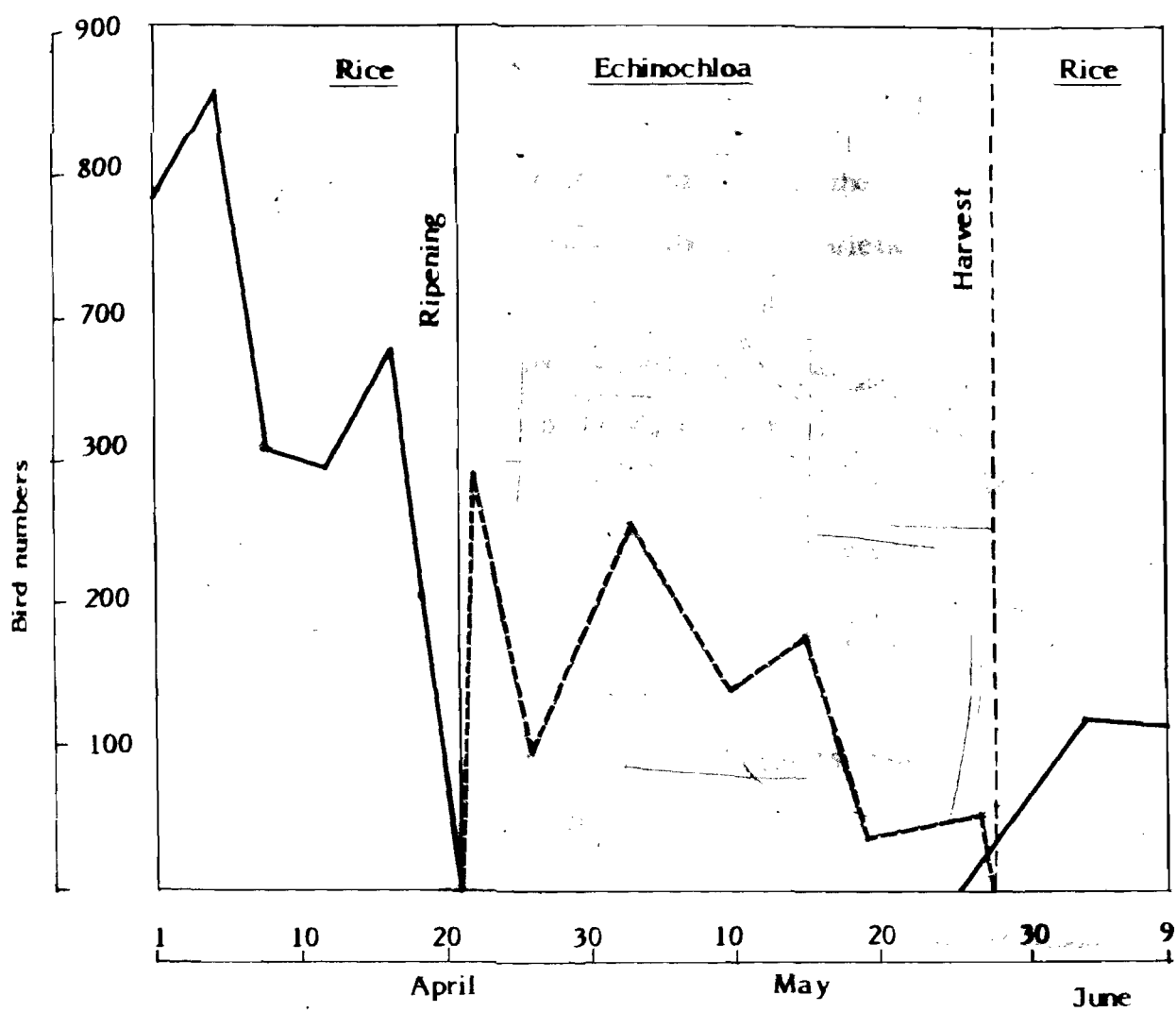


Fig. 26 Response of bayas and munias to the availability of *Echinochloa*.

a high correlation with projection of the flagleaf ($r = -0.7608$). Similarly, the length of the flagleaf showed a significant association with angle of the flagleaf and earhead type ($r = -0.4230$ and 0.4205 , respectively; Table 14). The spread of the plant was negatively associated with angle of flagleaf. Excluding these relationships, the analysis did not show any significant correlations among the remaining variables.

The hierarchical cluster analysis of the data thus obtained for all the seven varieties separated the seven varieties into two distinct groups (Fig.27). The first group comprised of varieties IR-36, IR-42, IR-48 and Pragathi and the second group had CT-1351, Doddabyra, Jenugudu. In the first group, IR-48, Pragathi and IR-36, IR-42 formed the separate clusters, while in the second group CT-1351 and Jenugudu formed a cluster while Doddabyra was held separately (Fig. 27).

The compatibility of bayas and munias was worked out by analysing 181 flock sightings between 1982 & July 1984 at HBL area. Details of the same is presented in Table 15. The analysis indicates the tendencies of different species to forage with other species or to feed on paddy as a pure flock. Of the five species considered black-headed munia, spotted munia and bayas showed the least tendencies to forage in pure flocks (25% of total sightings of each species) and were highly compatible with other species' feeding flocks. Red and whitethroated munias showed a greater tendency to segregate themselves and chose to feed in pure intraspecific flocks (50.00% and 78.95% of total sightings, respectively). The highly compatible species pair in

Table 15. Compatibility of different finch species at Hebbal study area*

	Number of sightings**					No. of sighting of each species* (X)	Pure flock as % of x
	Baya weaver-bird	Red Munia	White-throated Munia	White-backed Munia	Spotted Munia	Black-headed Munia	
Baya Weaverbird	16	2	2	36	48	30	18.39
Red Munia		30	1	1	5	5	78.95
Whitethroated Munia			4	0	3	1	50.00
Whitebacked Munia				15	33	18	23.08
Spotted Munia					13	30	15.66
Blackheaded Munia						5	10.20

* = House sparrows were not included because of their low numbers.

**n = 180 (mixed + pure flocks)

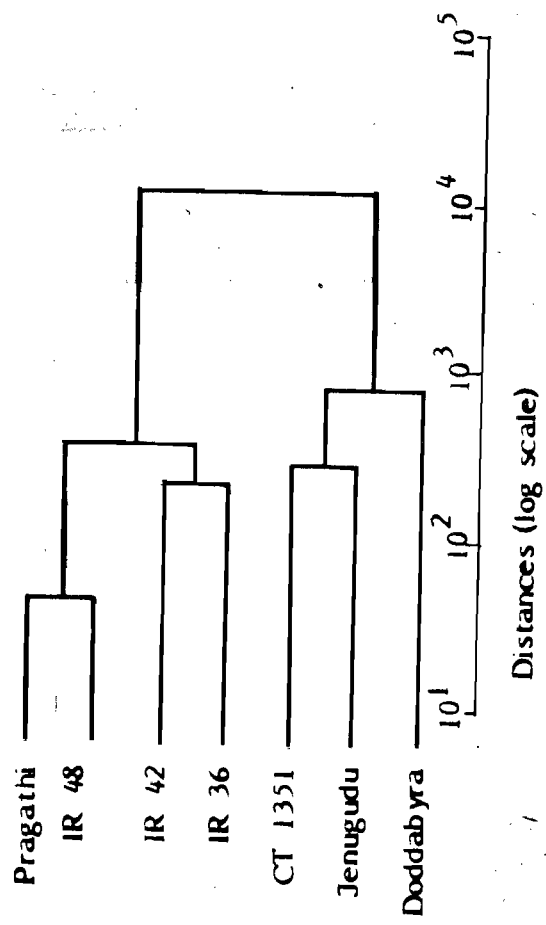


Fig. 27. Hierarchical cluster dendrogram of the varietal preference by finch pests at Hebbal area.

the decreasing order of compatibility were - spotted munia-baya (48 sightings); baya- white backed munia (36); spotted munia- whitebacked munia (33); baya-blackheaded munia (30); spotted munia- blackheaded munia (30), and whitebacked munia- blackheaded munia (18 sightings) Table 15).

4.7.1 Nesting habits of birds in and around rice fields

Ten bird species used paddy fields for nesting. In addition to these three more species were observed in vegetation in and around the study areas. The details on the number of nests of different species given in Table-16. At HBL study area bayas regularly built their retort shaped hanging nests (Plate 27) in the crowns of coconut palms. Spotted munias nested in the hedge and bushes outside HBL. A loose nesting colony of blackheaded munias were found in the sugarcane stand during 1983.

Paddyfield pipits and larks nested on the ground taking advantage of dried hoof marks of cattle or hollow depressions in the ground. No nests of redwattled lapwings were sighted at KGH, but birds tended to get alarmed at human intrusion in KGH.

The red munia, Indian wren-warbler, whitebrasted waterhen, streaked fantail warbler and bluebreasted banded rail required plant stands of different heights and differed in the height nest placement. The details of plant heights and nest heights from the ground are shown in Fig. 28. The first three species preferred to build nests in plots

Table 16. Details of the nests found in different study areas

Species	Number of nests			Nest site (s)
	Heb- bal	Naga- vara	Kodige- halli	
1. Bluebreasted banded rail	1	-	-	On standing rice
2. Whitebreasted waterhen	2	-	-	On ground, in a month old transplanted plot and on standing rice close to hedge
3. Redwattled lapwing			?	On ground, in dry uncultivated field in summer
4. Spotted owl	1	-	-	In the hollow of a mango tree trunk
5. Ashycrowned finchlark	-	-	2	In a depression or a hollow, in dry uncultivated field in summer
6. Skylark	-	-	1	In a depression or a hollow, in dry uncultivated field in summer
7. Streaked fantail warbler	121	11	6	Among the tillers of standing rice plant
8. Indian wren warbler	22	1	-	Nest on standing rice crop
9. Ashy wren warbler	1	-	-	Among the tillers of standing rice crop
10. Paddyfield pipit	1	-	6	In a depression or a hollow or dried hoof mark in a dry uncultivated field
11. Baya weaverbird	100	-	-	Nests hanging down from coconut fronds
12. Red munia	5	-	-	Close to the base, among the tillers of standing rice in the hedges along the tree line
13. Spotted munia	1	-	-	
14. Blackheaded munia	11	-	-	Close to the top of bundled plants in a sugarcane plot.

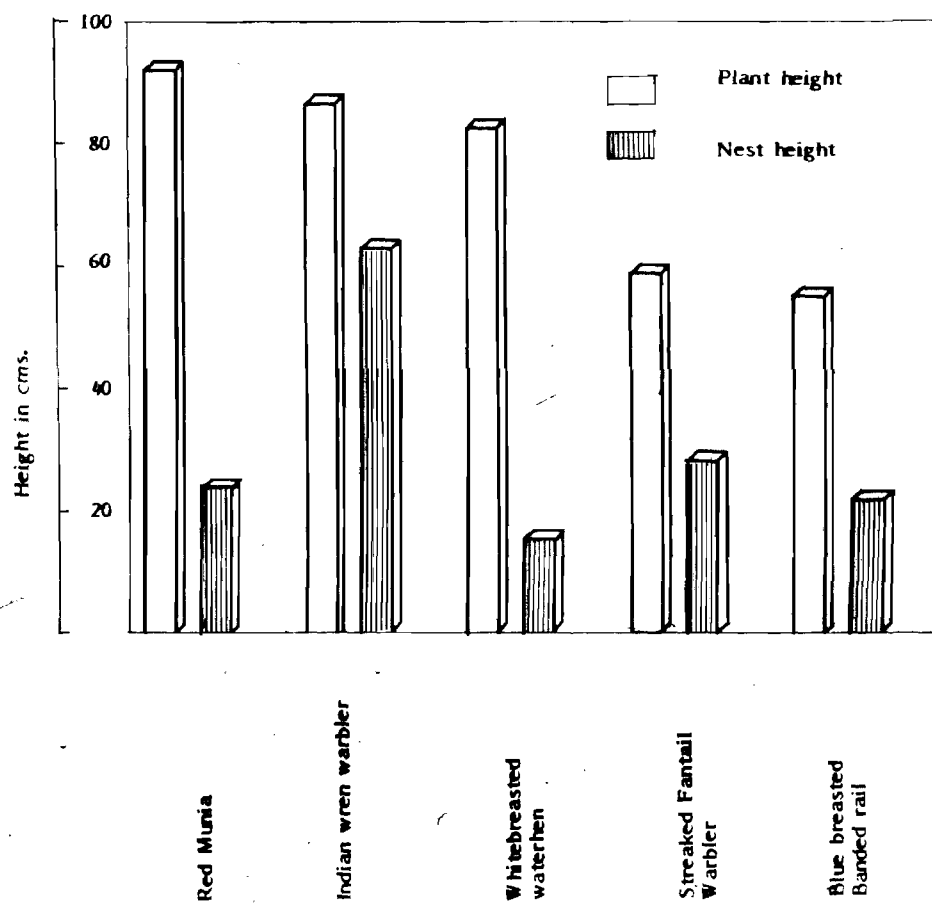


Fig. 28. Nest height differences in different bird species

with tall paddy, while the other nested in relatively dwarf plant stands.

Among the 10 species recorded nesting in paddy fields, streaked fantail warbler and indian wren-warblers had 138 and 23 nests, respectively (Table-16). The nest height of both the species was positively correlated with plant height (Fig.29) ($r = 0.619$ and $r = 0.685$, respectively $P < 0.001$); and both the species nested in plant stands of different heights ($P < 0.001$ Mann-Whitney U' test, one tailed)(Fig.30)

4.7.2 Nesting seasonality

Most nesting bird species showed a marked seasonality with respect to their nesting. The nesting seasonality of species that nested within rice fields and the species that fed on paddy grains from mature crop and nested elsewhere is presented in Table-17. The streaked fantail warbler and indian wren-warbler were observed nesting throughout the year except for a short break from mid January till the end of March. Pipits and larks nested only during March to May. Blackheaded and spotted munias started their nesting after June and continued till December. Red munias began their nesting from September and continued nesting till the end of January. Ashy wren-warbler and baya weaverbirds commenced their nesting during monsoon and continued till September-October. Ruddy crane's and Bluebreasted banded rail's nests were seen during June-July. Nesting activity of whitebreasted waterhen was observed from April till July. The young ones of ruddy cranes were seen till October. The young of whitebreasted waterhens were frequented till the end of August.

Table 17. Nesting seasonality of birds in rice fields of Bangalore

	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sep.	Oct.	Nov.	Dec.
1. Blue breasted banded rail							*****					
2. Ruddy crane							*****	*****				
3. Whitebreasted waterhen							*****					
4. Ashycrowned finchlark												
5. Skylark							***					
6. Streaked fantail warbler	****						*****	*****	*****	*****	*****	*****
7. Indian wren-warbler	****						*****	*****	*****	*****	*****	*****
8. Ashy wren-warbler							*****					
9. Paddyfield pipit							*****					
10. Baya Weaverbird							*****	*****	*****	*****	*****	*****
11. Red munia	****											
12. Blackheaded munia									*****			
13. Spotted munia									*****	*****	*****	*****

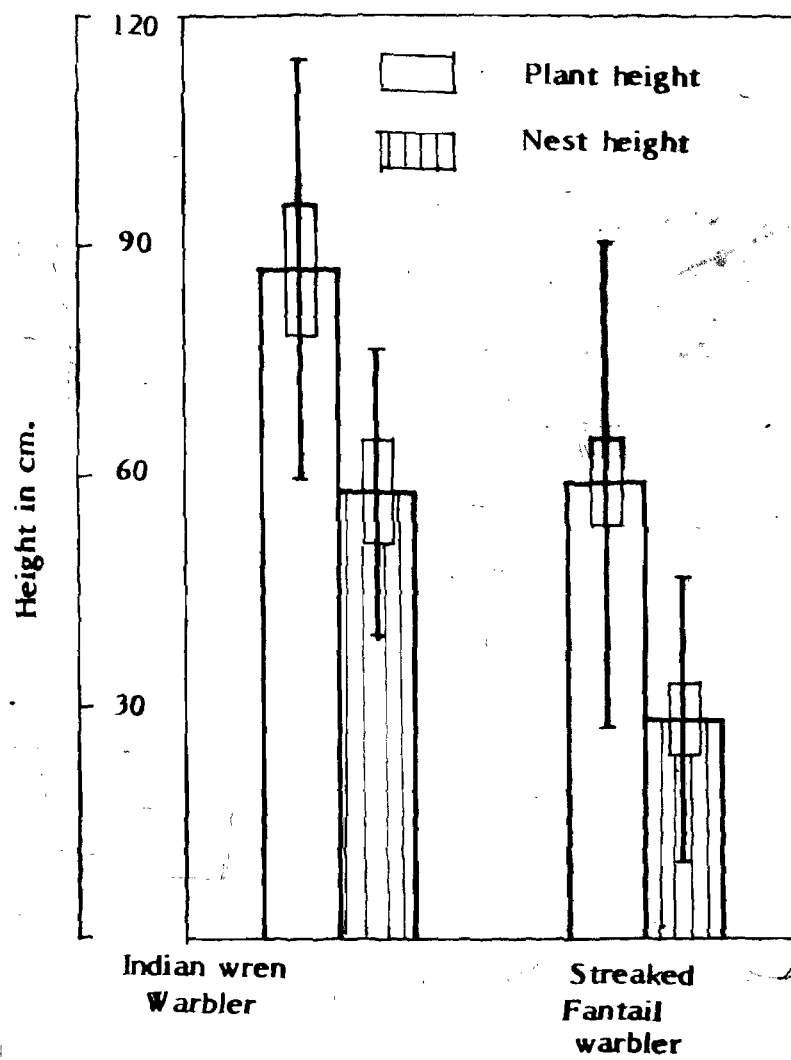


Fig. 29. Plant height preference and nest height differences in two insectivorous birds in rice fields of Bangalore

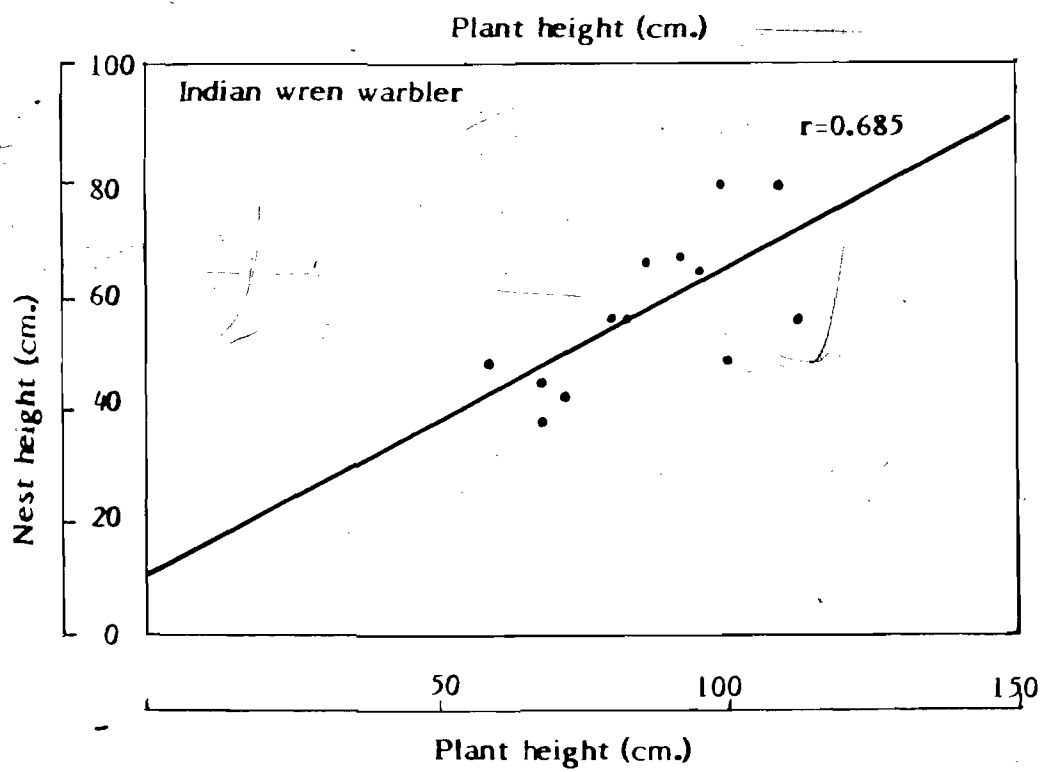
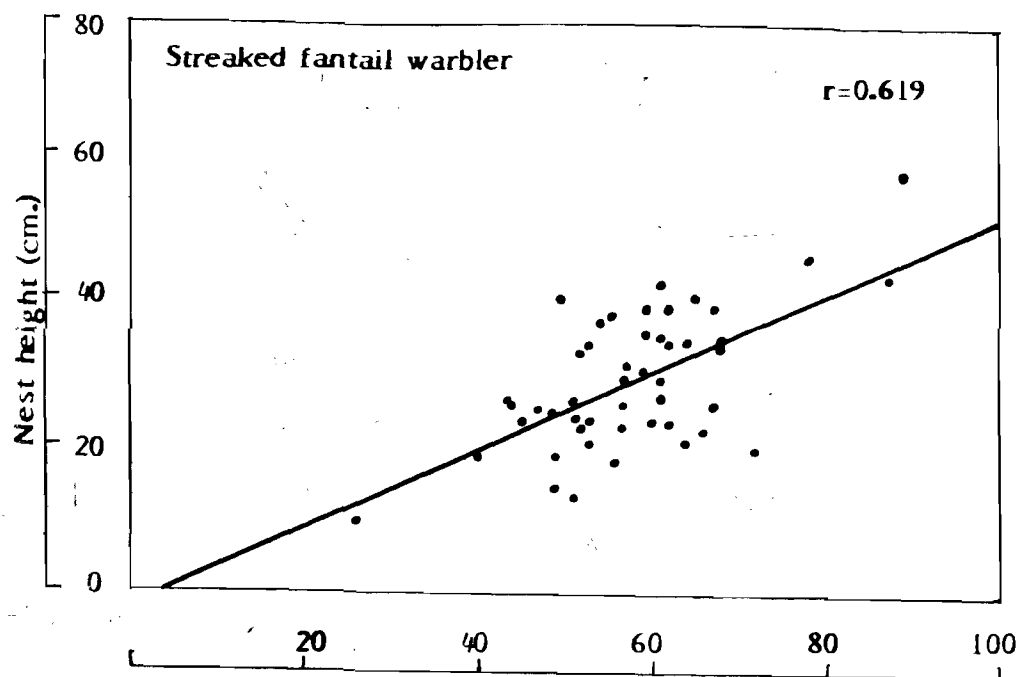


Fig. 30 Correlation between nest heights and plant heights in case of two insectivorous bird species.

4.7.3 Nests and nesting sites of the birds

The nests of whitebreasted waterhen and bluebreasted banded rail were shallow bowl-like, placed low down among the tillers of paddy in standing water. Young tillers and leaves of rice plants were pressed down to form a thick pad that formed the platform of nests (Plate-28). One of the nests of the waterhen was placed on the ground above a thick pad of fallen leaves of trees that grew close to the plot in which the nest was found. (Plate-29).

Pipits and larks nested in small bowl-shaped depression 10-14 cm deep. The nest was lined with animal hair, rootlets, dry grass and pieces of straw. One nest of a pipit was located in a wide dry crab burrow at the side of a bund at HBL.

Streaked fantail warbler, Indian and ashy wren-warblers built their nest in the standing crop of paddy. The nest of streaked fantail warbler was a flask shaped pouch opened at the top (Plate-30). The outer wall of the nest was built by vertically fastening the margins of leaf blades (Plate-31) of paddy with cobweb. Once this was built the birds lined the interior with dry leaves of paddy.

The nests of Indian wren-warblers were usually placed at the earhead level (Plate-32). The nest, a pear shaped structure with an entrance placed laterally at the top. The structure was neatly woven of fine grass fibres. Internally, the nests were lined with the dry rachis

Plate 27 : Hanging nest of the Baya Weaverbird.



Plate 28 : Platform shaped nest of the Whitebreasted waterhen built by using tillers of rice plants.



Plate 29 : Another nest of whitebreasted waterhen on the ground.



Plate 30 : Streaked fantail warbler at its nest.

Plate 31 : A close view of the nest of streaked fantail warbler built
midst the tillers of a rice plant.



Plate 32 : Nest of Indian wren-warbler, characteristically placed close
to earhead level on rice plants

of ass earheads which were held in place by cobwebs.

The nest of ashy wren-warbler was built out of loosely placed rootlets. The oval-shaped structure with a lateral entrance hole was placed among the tillers of paddy and was not bound to the tillers the nests of indian wren-warbler.

Baya weaver birds built retort shaped hanging nests (Plate-27) long entrance fully woven out of the strips of sugarcane and rice margins.

The munias built large untidy ball shaped nests with a lateral entrance hold. The nest of red munia was made completely of dried dry straw. The nest was placed between the tillers of rice (Plate-33). The nest of blackheaded munia were placed among the tops of sugarcane in bundles (Plate-34). The nests were usually over a meter above ground, and were made of sugarcane and grass leaves. The nests of munias were placed in the crown whorl of arecanut, in a thorny border or a dense hedge. Leaves of trees and grass leaves used profusely for nest construction. Several nests of blackheaded munias were also seen in the tall stand of giant napier grass at the Main Research Station of University of Agricultural Sciences, Bangalore.

The nests of streaked fantail and Indian wren-warblers, blue-banded rail and the whitebreasted waterhen were difficult



Plate 33 : Ball shaped nest of Red Munia placed among rice tillers.



Plate 34 : Nest of Blackheaded munia placed on sugarcane plants.

to locate. At times certain amount of searching was required to relocate a nest. The nests of rails, especially, were difficult to see even if one were to standing next to it.

4.7.4 Nesting success of birds in paddy fields

Nesting success of streaked fantail warbler and the Indian wren warblers was worked out and different mortality factors were noted. The partial life-tables constructed using the observation made on their nests is presented in Tables 18 and 19, respectively.

In the case of streaked fantail warbler six mortality factors were indentified as responsible for the loss of eggs. Addled or infertile eggs accounted for 3.27 per cent (14) loss of eggs, and 1.81 per cent (8) of eggs were lost due to structural deformity (Table 18). In the two nests where eggs were lost due to deformity of nest, the floor of the nest was pushed into the nest cavity unevenly due to one of the fresh growing tillers pushing the floor upwards. The birds were not observed visiting these nests for incubating the eggs and subsequently abandoned. Nearly 3.7 per cent of the eggs are abandoned for reasons unknown. One nest containing five eggs was abandoned by the female due to the lodging of the nest bearing plant.

A large percentage (29.71%) of eggs and young of streaked fantail warblers were lost due to predation and harvesting of the plants

Table 18. Partial life-table for Streaked Fantail Warblers nesting in rice Fields (October 1982 - June 1984)

Age interval	l_x^a	D x F Mortality factor	dx^b	$100qx^c$	$100rx^d$
Eggs	428	Addled or infertile	14	3.27	3.27
		Abandoned	16	3.74	3.74
		Structural deformity of nest	8	1.87	1.87
		Lodging of nest bearing plant	5	1.17	1.17
		Predation	17	3.97	3.97
		Harvesting	35	8.18	8.18
		Total	95	22.20	22.20
Nestlings	333	Predation	21	6.31	4.91
1 - 6 days		Harvesting	12	3.60	2.80
		Total	33	9.91	7.71
Nestlings	300	Predation	35	11.67	8.18
7 - 12 days		Harvesting	39	13.00	9.11
		Total	74	24.67	17.29
Fledglings	226				
% Fledged	52.80	% Total Mortality :			47.20

^a l_x = Number alive at the beginning of x

^b dx = Number dying during x

^c $100x$ = dx as a percentage of l_x , apparent mortality

^d $100rx$ = as a percentage of the number at the beginning (eggs), real mortality.

bearing the nests. Predation was responsible for the loss of 3.97 per cent of eggs, 4.91 per cent of young during early nestling period and 8.18 per cent during late nestling period.

Bandicoots *B.benghalensis* and a snake were seen on several occasions inside paddy fields and on few instances close to predated nests. However, both these were not seen actually removing the nest contents.

Differences existed among the predated streaked fantail warblers' nests. The predated nests were either torn apart into shreds or in few cases a large hole was made at the base of the nest. In other cases the contents were simply removed without damaging the nest. Predation alone accounted for 13.09 per cent loss of young ones in addition to the loss of 3.97 per cent loss of eggs.

Maximum loss of egg and young ones were observed during harvesting (20.09%) when the labours cut the nest bearing plants. Egg and late nestling period had 8.18 and 9.11 per cent loss, respectively, while during the early nestling period only 2.80 per cent loss.

The overall loss of egg and young put together was 47.2 per cent and of the 428 eggs from 125 nests recorded only 226 (52.8%) could successfully fledge out of the nests of streaked fantail warbler.

No loss of young ones was noticed in case of indian wren warblers wherein 40 eggs were recorded from 12 nests (Table 19). No loss of young in either of early or late stage were observed. A loss of 4.50 per cent of eggs were due to addled or infertile eggs, predation and harvesting. Harvesting of nest bearing plants took a toll of 32.50 per cent of eggs while predation accounted for only 10 per cent of egg loss (Table 19).

The nesting success of other species nesting in rice fields could not be worked out due to their meager numbers.

**Table 19. Partial life-table for Indian Wren-warbler in rice fields
(October 1982 - June 1984)**

Age interval	l_x^a	D x F Mortality factor	dx^b	$100qx^c$	$100rx^d$
Eggs	40	Addled or infertile	1	2.50	2.50
		Predation	4	10.00	10.00
		Harvesting	13	32.50	32.50
		Total	18	45.00	45.00
Nest lings	22		-	-	--
1 - 6 days		Total	-		-
Nestlings	22		-		-
7 - 12 days		Total	-		-
Fledglings	22				
% Fledged	55	% Total Mortality			45%

^a l_x = Number alive at the beginning of x

^b dx = Number dying during x

^c $100x$ = dx as a percentage of l_x , apparent mortality

^d $100rx$ = dx as a percentage of the number at the beginning (eggs), real mortality.

DISCUSSION

V DISCUSSION

5.1.1 Composition in Rice fields

Of the 81 species recorded during the study (Appendix IIa) 41 species were common with those recorded by Ali and Ripley (1968-74) and the remaining species are recorded during the present study as frequenting rice cultivations. These birds were the blackwinged kite, shikra, redheaded merlin, pale harrier, pheasant-tailed jacana, yellow-wattled lapwing, *Capella* sp., brownheaded gull, blue rock pigeon; roseringed parakeet, spotted owlet, house swift, palm swift, pied kingfisher, small blue kingfisher, small green bee-eater, Indian roller, hoopoe, skylark, brown shrike, rosy pastor, jungle crow, ashy wren-warbler, tailor bird, great reed warbler, blyth's reed warbler, bluethroat, greyheaded yellow wagtail, grey wagtail and house sparrow.

Little green herons, chestnut bitterns, baillon's crake and kora were very infrequently sighted. Their activity may be much higher than observed during the study because of their secretive or concealing habit (Ali and Ripley, 1968-74).

None of the ducks mentioned by Ali and Ripley (1968-74) were recorded during the study period, although, once a pair of spotbilled ducks (*A. poicelorhyncha*) were seen in a nearby deeply flooded paddy field during 1983 monsoon.

Ducks are reported to spend the nights feeding in rice fields (Mason and Lefroy, 1912; Giglioli, 1957; Ali and Ripley, 1968-74;

Wouters, 1963; Grist and Lever, 1969; Brown, 1969; Ratanaworbhan, 1982), but none were seen in the study areas during night or any observations to this effect were made by the farmers. However, a garganey was found killed by a marsh harrier (Appendix VI at NGR suggesting that this area might have been frequented by ducks.

Geese are also known to be the pests of paddy (Longfield and Moir, 1961; Grist and Lever, 1969). But no Indian species of goose was recorded frequenting the study areas. This could be due to the rarity of geese in south India (Ali and Ripley, 1968-74). Similar absence of other groups like moorhens (Grist and Lever, 1969; Anon, 1976; Mason and Lefroy, 1912) was observed.

Birds like the median egret and openbilled storks, were irregular visitors (Appendix -VI). These birds are common in rice fields adjacent to and around the Ranganathittu bird sanctuary near Srirangapatnam where they breed close to Mysore and also in rice fields at Mandya about 150 km from the study area. It is suspected that these birds may be local migrants from their breeding grounds.

Jacanas have been reported to feed on paddy grain (Wouters, 1966) but the pheasant-tailed jacanas were seen at NGR several times when no paddy grain was available at the study area. Bronzewinged jacanas were observed in rice fields of Kerala during June 1983 by the investigator, feeding in transplanted fields.

For the first time, Greyheaded lapwing was recorded in South India during the study period (Appendix-IIIa). Although it is a very

regular migrant to north-eastern and northern India (Ali and Ripley, 1968-74), the present sighting indicates the bird to be a straggler as it is at Kashmir, Andamans and Rajasthan from their breeding grounds in Mongolia and southern China.

The occurrence of brownheaded gulls only at HBL and NGR area during winter (Fig. 8, 9) indicate that their visit to these study areas could have been due to the proximity of the two study areas close to irrigation tanks (Fig. 1), as brownheaded gulls are known to frequent such water bodies during winter (Ali and Ripley, 1968-74).

Plaintive cuckoos foraging in rice fields appear unusual. But both at HBL and KGH this cuckoo was seen picking up insects close to the tree line wherein the numbers of cuckoo family usually skulk. Further, Ali and Ripley (1968-74) and Becking (1983) indicate that plaintive cuckoo (*Caocomantis merulinus* Scopoli) to be brood - parasitic on small warblers (Sylvinae) such as, representatives of genera *Prinia*, *Cisticola*, *Orthotomus*. These fosterers are birds of rather open habitats such as savanna grasslands, village gardens, plantations and secondary forest. In conformity with this, *C. merulinus* is a cuckoo of open habitats and secondary forests and is never found in dense primary forest. He also indicates that streaked fantail warbler and Indian wren-warblers are hosts for the cuckoo. Hence, the nesting activity of these two insectivores at HBL and KGH, would probably explains the presence of the cuckoo at the two study areas.

Among the birds of prey, *brahminy kites*, *marsh harriers* and

the redheaded merlins were important in rice fields, while others appeared to be of minor importance due to the low frequency of their visits (Appendix - V). Also, no instance of the species of minor importance feeding actively in the study areas was observed.

The spotted dove, hoopoe, babblers, pied bush chat, tailor bird and ashy wren-warblers may have come to the study areas from the adjoining dryland cultivation at HBL. However, Mason and Lefroy (1912) have recorded several orthopterans (*Chrotogonus* sp., *B. achatinus*, *G. africana*) which are usually found in rice fields (Grist and Lever, 1969; Anon, 1976) in the stomachs of these birds.

Thirumurthi et al. (1981), Nathan and Rajendran (1982) and Sridhara et al. (1984) have reported that the tree pie, redvented bulbul, paradise flycatcher, koel, goldenbacked woodpecker, purple sunbird, pied crested cuckoo, blackheaded cuckoo-shrike and the coppersmiths feed in rice fields. But, according to Ali and Ripley (1968-74) and Whistler (1949) these birds are chiefly arboreal and greatly dependent on vegetation and inhabit areas of lightly wooded or open scrub areas and their diet comprises largely of fruits and berries, flower nectar or insects and other animal matter. Hence, it is thought that these birds could have been recorded from vegetation (bushes and trees) in and around rice fields, but have not been observed feeding in rice plots.

In the present study also several other species including grey headed mynas, redvented bulbuls, koels, small green barbets, coppersmiths, goldenbacked woodpeckers, paradise flycatchers, sunbirds, were observed

in the adjoining tree line at HBL and KGH, but these birds were not considered during the census as they never utilized the rice fields for feeding, nesting, cover or roosting.

Paddy field seems to be one of the major habitat of Bluetits, as it was observed in the present study. Ali and Ripley (1968-74) have not reported sighting them in paddy fields. They were sporadically seen singly or in low numbers in vegetation near tank edges, stream sides, grassy marshes in and around Bangalore during the present investigation.

The greyheaded yellow wagtails were seen in rice fields during the present study. They are otherwise known to restrict themselves to pastures and moist grassy grounds, especially along riverside and on wheel margins (Ali and Ripley, 1968-74).

The larks, pipits and rollers occurred only when dry uncultivated plots were available suggesting their preference to such habitats (Ali and Ripley, 1968-74).

Paddy fields appear to be an important breeding habitat for the streaked fantail warblers. These birds are considered to be monogamous by Ali and Ripley (1968-74), but during the present study and also according to Udea (1984) and Avery (1982), the males of this species were polygynous.

Unlike in other areas in India (Mehrotra and Bhatnagar, 1979; Anon., 1979) sparrows were not serious pests of rice in Bangalore. On

the other hand, they are known to feed on kitchen scraps, grass seeds, occasionally on parthenium flower heads (Ali and Ripley, 1968-74), which were abundant around HBL and KGH. They were seen occurring frequently at Nagavara area with flocks as large as 143 individuals, visiting rice fields. This may be due to its rural set up and the lack of alternate food availability may have forced them to feed more frequently on rice at NGR.

Although earlier reports suggest that baya weaverbirds to be important bird pests of rice (Mukerjee and Saha, 1974), Mathew, 1976; Meharotra and Bhatnagar, 1979; Dhindsa, 1980; Anon., 1979), they were only second to spotted munias in rice fields of Bangalore (Appendix-VI, Fig. 8, 9, 10). The spotted munias have very diversified and ample nesting habitats in Bangalore enabling prolific breeding, resulting in higher population. This is probably why it is the most important bird pest of rice. However, munias are known to be important, principal pests of paddy in south-east Asia including Malaysia (Grist and Lever, 1969; Saha and Mukherjee, 1978; Avery, 1980), whereas weaverbirds are known to be serious pests in Africa (Grist and Lever, 1969 and Anon., 1975).

5.1.2 Residency status of birds in rice fields

Broadly, the birds frequenting rice fields recorded during present study can be classified into resident species and migrant species (Ali and Ripley, 1968-1974). Based on the activity of birds in rice fields, the residents can be further subdivided into breeding residents and non-breeding residents.

Breeding residents : Some of the residents use different conditions in rice fields for nesting, but the nesting species composition and intensity of nesting activity (Table-17) by these species may vary between different study areas. Thus, at HBL the bluebreasted banded rail, ruddy crake, whitebreasted waterhen, spotted owlet, streaked fantail warbler, Indian wren-warbler, baya weaverbird, red munia and blackheaded munia were found nesting regularly and more than one nest or family parties containing young ones were observed more than once in the study area.

The regular breeders recorded at NGR were bluebreasted banded rail, ruddy crake, streaked fantail warbler and Indian wren-warbler only. But at KGH, in addition to the three regular breeders namely, bluebreasted banded rail, streaked fantail warbler and Indian wren-warbler, four other ground nesting species like redwattled lapwing, ashycrowned finch lark, skylark and paddyfield pipit were recorded. These ground nesters were seen nesting at KGH mainly because, KGH is not next to a village irrigation tank as it is the case with HBL and NGR. As a result nearly 60 per cent of the study area at KGH was left uncultivated after the monsoon planted crop was harvested. Hence, the ground nesters were attracted to this situation.

At HBL the whitebreasted waterhen was found nesting in plots close to tree line separating the study area from the adjoining dryland cultivation (Table-17), such activity of nesting close to the hedge has been suggested by Ali and Ripley (1968-74). The nesting activity of spotted owlet, baya and the blackheaded munia were probably due to the availability of additional vegetation (Table -17).

Among the species that nested irregularly were the Ashy wren-warbler, paddyfield pipit and largepied wagtail at HBL, spotted dove and large-pied wagtail at NGR and none of these were recorded at KGH area. The irregular nesting status may have been due to the non-availability of suitable nesting conditions outside rice fields.

Non-breeding residents :

Hebbal area recorded 21 species of regular residents while the same for NGR and KGH were 20 and 16. The resident species considered under this category were either seen frequently and/or in good numbers (Appendix IIIa & V). These species at HBL were predominantly made up of ground forager (pond heron, cattle egrets, little egrets, redwattled lapwing, blue rock pigeon, spotted dove, common and jungle mynas, house crow, roseringed parakeet); the aerial foragers (brahminy kites, redheaded merlin, house swift); granivores (baya weaverbird, white-throated munia, whitebacked munia and spotted munia) and kingfishers (whitebreasted and pied kingfishers).

The regular residents at NGR did not have two species that were found at HBL namely, spotted dove and whitebacked munias, instead had house sparrow, red and blackheaded munia as resident regulars. Nagavara area had only 16 species as regular residents (Table-2). They were the pond heron, cattle egret, little egret, brahminy kites, blue rock pigeons, roseringed parakeets, spotted owlet, house swift, white-breasted kingfisher, common myna, jungle myna, house crows, redheaded merlin, baya weaverbird, spotted and blackheaded munia.

Irregular residents included only those resident species which were either seen infrequently or those that were abundant in some other habitat, but were seen in rice fields infrequently as these species still could use rice fields as one of the feeding habitats.

The irregular residents seen at HBL were the little green heron, chestnut bittern, smaller egret, blackwinged kite, shikra, plaintive cuckoo, palm swift, small blue kingfishers, small green bee-eaters, Indian roller, hoopoe, redrumped swallow, black drongo, jungle crow, whiteheaded babbler, tailor bird and the pied bush chat (Fig. 8, Appendix-V).

The irregular residents seen at NGR were the little green herons, chestnut bittern, smaller egret, redheaded merlin, yellow-wattled lapwing, small green bee-eater, Indian roller, redrumped swallow, black drongo, jungle crow, paddyfield pipit, pied bush chat, and whitebacked munia. While the same at KGH were openbilled stork, whitebreasted waterhen, spotted dove, plaintive cuckoo, Indian roller, black drongo, large pied wagtail, streaked weaverbird and red munia. The single openbilled stork seen at KGH appeared to be a local migrant to the study area from its breeding area (Appendix-IIIa). Mukherjee (1963-73) indicate rice fields to be one of the important feeding grounds for egrets and openbilled storks.

The reason for the irregular status appears to be that the little green heron and chestnut bitterns belong to tall reedy swamps; likewise blackwinged kite and shikra usually frequent dryland areas. Palm swifts occurrence is closely associated with palms especially the palmyra

(*Borassus fabellifer* (L.)) and locally with bettlenut palm (*Areca catechu*(L.)) and HBL had a dense stand of 43 Areca palms. Again the small green bee-eater, Indian roller, hoopoe, pied bush chat, yellow-wattled lapwing drongo, jungle crow, whiteheaded babbler and the tailor bird usually belong to either dry open or lightly wooded areas or garden lands (Ali and Ripley, 1968-74). Small blue kingfisher is a bird of relatively deep water ponds, tanks and lakes and HBL was closer to a large tank where this species was abundant. As mentioned earlier the brood parasitic habit of plaintive cuckoo as streaked fantail warbler and Indian wren-warblers (Ali and Ripley, 1968-74 and Becking, 1983) might have drawn the species to HBL and NGR areas as both these warblers were regular nesters at HBL and KGH. Smaller egrets might have strayed into the study areas from the adjoining marsh at HBL and NGR areas, where the species was common.

Migrants

Among the 28 migrants, there was difference in species composition between different study areas (Table-2). Several reasons can be attributed to their abundance in different study areas. The marsh harrier, little ringed plover, green sandpiper, spotted sandpiper, common sandpiper, little stint, snipe (*Capella* sp.) blackwinged stilts, painted snipe, common swallow, and grey wagtails are known to inhabit a variety of freshwater wetlands in inland areas (Ali and Ripley, 1968-1974). The paddyfield warbler is very peculiar to rice fields; brown shrikes and yellow wagtails are widespread common migrants during winter (Ali and Ripley, 1968-74).

The regular migrants, both at NGR and KGH included the marsh harrier, little ringed plover, green and spotted sandpiper, snipe (*Capella* sp.) little stint, blackwinged stilt, common swallow, brown shrike, paddyfield warbler, bluethroat and yellow wagtail.

Several migrant species frequented rice fields irregularly. For the species coming under this group, paddy field was not one of the preferred habitat. Also, this group included species which were very common in at least one of the study areas and irregular in others. Thus the brownheaded gulls and wiretailed swallows were seen at HBL and NGR as these species were frequently seen in adjoining irrigation tanks. Marsh sandpipers and temminck stint although of coastal species were seen at both the above areas because both the areas had vast marshy habitats close to them. Besides, marsh sandpipers are numerically least abundant of the sandpipers in India according to Ali and Ripley (1968-74). The great reed warbler and watercocks that were observed daily in paddy field, are inhabitants of tall reedy swamps (Ali and Ripley, 1968-74), again seems to have strayed into rice fields.

At NGR in addition to brownheaded gull, marsh sandpiper, temminck stint and wiretailed swallows, the pheasant-tailed jacana and common sandpipers were irregular migrants. Common sandpiper is another of the migrant sandpiper that occurs in low numbers (Ali and Ripley, 1968-74).

At KGH irregular migrants included only the common sandpiper and the brown shrike. The latter was seen only once and this species was a regular migrant in other two areas where it was seen frequently

perched in the tree line vegetation. Hence, its abundance was dependent on vegetation around the study areas.

Similarly, at HBL, the transients, pale harrier, Bailon's crane, ashycrowned finch lark and rosypastor might have strayed into the study area. According to Ali and Ripley (1968-74) pale harriers are partial to dryland cultivation, stony semidesert and scrub area, while bailon's crane is considered as a passage migrant during winters. The migrant rosy pastors have been observed to start the return journey to their breeding grounds in Southeast Europe and Southwest Asia by March, April and are known to rest in areas with tree fringes in neighbourhood of cultivation. The flocks that visited HBL in March could be one such migrating flock. Ashycrowned finch-lark could also have strayed into HBL and NGR from adjoining dry areas.

At NGR in addition to the finch-lark, pale harrier was recorded as a transients, while at KGH area only the greyheaded lapwing and golden plovers considered transients (straggler) as both were seen only once. Of these two, golden plover is a coastal species, that strays inlands very rarely, while the greyheaded lapwing which is a common migrant to North eastern India and Nepal from Mongolia and south China appeared to be a straggler.

5.1.3 Utilization of rice fields by birds

Bird species differ in their dependence on rice fields to derive their requirements namely, food, nesting cover and roosting. Based on the extent of dependence, birds of rice fields can be grouped into the following seven categories.

Food, cover, nesting and roosting :

Only a small percentage (6.17%) (Fig.3) of birds were found to derive all the above four life requirements from rice fields. This group includes three species of rails (the bluebreasted banded rail, ruddy crake and the whitebreasted waterhen) and two species of warblers (streaked fantail and Indian wren warblers). According to the order of their abundance and commonness, streaked fantail warblers stand first, followed by Indian wren warbler, whitebreasted waterhen, ruddy crake and the bluebreasted banded rail (Appendix IIIb).

According to Ali and Ripley (1968-74) streaked fantail warbler is found only in rice fields in the Himalayas, whereas here it is found often in other habitats also, but more common in rice fields. In Himalayas, other than rice fields no other areas may afford all the requirements of the bird, thus confining only to rice fields.

The secretive habits of the rails (Ali and Ripley, 1968-74; Whistler, 1949) makes it difficult to sight these birds even if they are in good numbers.

Food, cover and nesting :

The second group that use rice fields for food nesting and cover include only two species namely, the ashy wren warbler and the red munia (Appendix-IIIa). These two species were dependent on the cover of standing paddy while feeding and for nesting. The former species usually found in well vegetated dryland areas seems to have strayed

into rice field for feeding. Red munia has the habit of feeding on grain inside the cover of standing rice crop.

Food cover and Roosting :

The third group includes species that use the cover (Kendeigh, 1974) offered by the standing rice crop for feeding and roosting and remain hidden. This group comprises species that are highly skulking or secretive in habit, and therefore finds the conditions in rice fields conducive. The bird species were baillon's crake, kora or the watercock, *Capella* sp. painted snipe, paddyfield warbler and the bluethroats. All these species happen to be either local migrants or migrants from North India or Palaearctic Region (Ali and Ripley, 1968-1974), hence, they do not use the areas for nesting.

Nesting and Feeding :

The birds nesting and feeding in rice fields were ground nesting species, which did not need the cover of emergent crop of rice (ashycrowned finch-lark, skylark, paddyfield pipit and the redwattled lapwing) and two granivorous species (baya weaverbird and blackheaded munia), which built their nests in vegetation other than paddy in the study areas. All these species were residents (Ali and Ripley, 1968-1974).

Feeding and cover :

Birds species that frequented rice fields only to feed in safety of cover offered by standing crop of rice, were the skulking species (little green heron, chestnut bittern, great and blyth's reed warblers,

tailor bird and the greyheaded yellow wagtail). The last species occasionally foraged between the base of standing crop when plots were dry. Except the last species, all the above species remained within the cover of standing paddy crop. It was not known whether these species roosted in standing paddy inside the study areas. All these, except the tailor bird and yellow wagtails were seen only once, and the great reed warbler twice (Appendix V, Fig. 8) in the study areas. Tailor birds roosted in bushes or tree line, while the yellow wagtails have the habit of roosting along with the weaverbirds and munias (Gadgil and Ali, 1975; Ali and Ripley, 1968-74).

Feeding and roosting :

Use of rice fields for feeding during the day and roosting during the night was limited to ground foraging species like golden plover, little ringed plover, green sandpiper, common sandpiper, little-stints and temminck stints and blackwinged stilts. While other ground foraging waders fly out to roost elsewhere (Ali and Ripley, 1968-74), the above species remained in the study areas. All the species included in these categories are migrants either from north India or Palaearctic Region (Ali and Ripley, 1968-74). Being open area feeders rarely do these species require any cover while feeding or roosting.

Only feeding :

A large majority of birds (60.49%) (Fig. 3) frequent rice fields only for food, but the degree of dependence on rice fields might vary with different species. These include several open ground foragers

like herons, egrets, storks, jacanas, lapwings, sandpipers, doves, pigeons, parakeets, hoopoes, mynas, crows, babblers and wagtails; aerial foragers like the birds of prey, bee-eaters, drongo, swifts and swallows; grain feeding birds like, weaver birds and munias and others like chats and shrikes.

The above patterns of utilization of rice fields indicate one common feature among all the birds that inhabit rice field, that they use rice field mainly for food, but the degree of dependence on rice fields varied with different species. Only a few selected species are able to derive their food, nesting, cover and roosting requirements. However, rice fields, being one of the highly productive habitats with the primary productivity being above 10,000 kg/ha each season (Avery, 1982), are able to meet the food requirement of bird species of varied dietary needs.

Further, the high specialization of the first group (a) of five species indicate that a continuous loss of suitable conditions may result in a drastic reduction in their population. The other groups with reduced dependence may not be affected by habitat destruction. The works of Ali and Ripley (1968-74), Lack (1958) and Whistler (1949) show that these species have remarkable habitat tolerance. The last category in the above groups may not get affected by changes and loss of suitable conditions and behave as dietary opportunists (Pianka, 1978) and inhabit different types of field conditions.

5.1.4 Succession of birds in rice fields

Successional trend over 12 major field types or ecophases

(Hejny and Husak, 1978) indicate a rapid turnover of bird species in rice fields. It could be seen from the Appendix-IV and Fig.7 that these changes encompass mainly two groups of birds, that is, species associated with open field and low vegetated conditions and species associated with standing crop of paddy of different age. In other words, the successional trend shows a gradual shift from ground foragers to vegetation (rice crop) dependent foragers. These ground foragers like herons, egrets, storks, larks, pipits, lapwings, plovers, sandpipers, stints, stilts, snipes, wagtails, crows, mynas, predominate rice fields before transplanting. A high degree of similarity exists (Table-7) among these ecophases with respect to species composition.

As the transplanted rice start to produce tillers and the crop reaches close to flowering and subsequent grain filling and grain maturing stages, most of these ground foragers are gradually replaced by vegetation dependent foragers like insectivorous warblers, granivorous baya and munias. Also, several ground foraging birds like bluethroats and rails that are skulking in habit (Ali and Ripley, 1968-74) and hide in the cover of standing paddy inhabit the field during this stage. The granivorous birds like parakeets, weaverbirds and munias do not invade the fields till the grains are produced.

At harvest, majority of species that show a high dependence on standing rice crop disappear only to be replaced again by several of the ground foragers that earlier frequented the field conditions from ploughing till transplanting. The only additions here are the ground foraging granivores (pigeons, whitethroated munia and the parakeets) (Appendix-IV).

However, several bird species like the aerial foraging swifts, swallows, drongo, kites, plot edge foragers like pond herons, white breasted kingfishers and common mynas are common to all the stages as they switch their feeding behaviour accordingly to suit the altered habitat conditions. Only one species, the cattle egret, which is predominantly a ground forager is seen in plots with standing paddy field.

The main reason for such a shift appears to be the modification of field conditions unsuitable for ground foragers. The growing rice plants, in nurseries after transplanting stage would reduce the space available for foraging and the addition of tillers would restrict the mobility of ground foragers. In addition, the visibility of the ground for the ground foragers which usually glean prey items from the surface of the ground may be reduced. Cody (1968) observed such changes in avifauna in North American grassland with changes in vegetation structure.

This pattern of species preference to foraging in different field conditions indicates that various species inhabiting each ecophase differ by their ecological niches and the availability of the habitat conditions that makes these niches available determine the species presence (Pitelka, 1941; Wiens, 1969; Hudec and Statstny, 1978).

Changes in avifauna are associated with successional changes in field conditions. In nature, such changes can occur. Avifaunal changes due to natural process can be seen during the successional of an old abandoned field (Johnston and Odum, 1956), or in newly formed lakes (Dannel and Sjoberg, 1982).

Changes in avifauna due to alterations happen in two ways either naturally due to fire (Smith, 1965), grazing (Smith, 1965; Wiens, 1978; Bell, 1970) or by human activity like silvicultural practices (Crawford and Titterington 1979; Crawford *et al.*, 1981); commercial clear-cutting (Titterington *et al.*, 1979); fire and logging (Blake, 1982).

Similarly, the successional trends in rice fields is also brought about by human interference. Different cultivation practices taken up in preparation of uncultivated land, transplanting and harvesting induce similar changes as indicated above by creating a varied types of field conditions.

However, few differences exist between the bird succession in paddies and the usual terrestrial or aquatic successional patterns.

The succession of birds in rice fields can be termed as passive (Price, 1975) as the bird species involved with each successional stage (i.e., field conditions) does not radically induce changes into the system they occupy but merely respond to the changes brought about by cultivation practices and growth and development of rice crop. Few examples of such passive successional are that of pseudoscorpions on sand banks of North Carolina mainland, where the distribution of nine species of pseudoscorpions changed in relation to development of vegetation (Weygoldt, 1969) and of tiger beetle succession on sand dunes (Shelford, 1907).

Secondly, bird species are known to show a progressive increase in species composition with succession in any terrestrial or aquatic environments (Kendeigh, 1974; Price, 1975), but, the bird succession

in rice fields shows a bimodal trend in species composition. This is mainly because the species number drops in nurseries as the ground is completely covered by dense growth of seedlings and lowest number of species seen when the crop is in early tillering stage. At this stage the ground is covered to the extent that it is unsuitable for ground foragers and at the same time the crop is not grown to the required extent, to suit vegetation dependent foragers. In other words, the field stages from nursery to early tillering stages appear to be critical stage at which most of the ground foragers try to be away from such situation while, vegetation dependent foragers start arriving. However, the birds frequenting open ground like the aerial foragers and plot edge foragers can still be found in the later stage (Appendix IV). Johnston and Odum (1956) who studied the bird populations along a successional gradient in the Piedmont of Georgia and found a similar bimodal pattern of species abundance (Fig.7). The number of species increased during the early stages of old field succession, declined during early forest stages, and then increased again in the mature forest. Odum (1963) suggests that during succession, an increase in potential niches results from an increased biomass, and vegetation stratification. Hence, changes in bird population during successions are known to conform with changes in habitat conditions and other species of animals and plants (Glue, 1971).

Thirdly, another main feature of rice field bird succession is its 'temporal shortness' which equals a single crop growing season beginning from ploughing to harvest to ploughed again for next crop, while succession in nature is a gradual, and continuous replacement of one kind of species

group by another till the community itself is replaced and the process is spread over years (Smith 1965, Odum, 1963).

Since, there are two growing seasons, it is reasonable to expect the absence of few species in both the ground foragers and vegetation dependent foragers, as a result of seasonal migration (Ali and Ripley, 1968-1974). During the monsoon growing season that begins after May-June there will be the absence of several species of ground foragers as the migration will not have started yet, whereas during the summer growing season several vegetation dependent foragers and skulking ground foragers will be absent from March, April onwards as they will have migrated back to their breeding grounds in northern latitudes (Ali and Ripley, 1968-74; Welty, 1982). The absence of migrant ground foragers will also affect the species composition in field conditions after harvest of summer crop.

5.1.5 Nature and characteristics of rice field avifauna

When the species composition of birds in the study areas (Appendix-IIIa) their association with different rice field conditions (Appendix-IV and Fig.6) and their feeding habits (Appendix-VI) are considered together, it becomes evident that the birds visiting rice fields come from two distinct habitat pools, i.e., the marshland and grassland habitats.

Marshes are fringe habitats and are of amphibious environments, characterized by very shallow water with predominantly emergent vegetation (Welty, 1982). Reedy marshes and swamps are extensions of shoreline habitat (Welty, 1982). Vegetation and food are unusually abundant in

these habitats (Welty, 1982). The grass lands are flat featureless habitats with grasses as the dominant vegetation (Welty, 1982). Under Indian conditions, these grasses have annual seasonal cycles, often linked with monsoon, the onset of which induces luxuriant growth of these grasses (Singh and Joshi, 1979).

Long wading legs, agile necks are common features with some of marsh inhabiting birds (Welty, 1982). Certain sandpipers, that are typically found along the muddy shores or sandy shores also inhabit these habitats and these birds usually have long probing beaks (Welty, 1982). The studies of Hudec and Statsny (1978) indicate that birds of reed swamps encompass the genera *Ardea*, *Ixobrychus*, *Circus*, *Larus*, *Phasianus*, *Rallus*, *Porzana*, *Acrocephalus* and *Motacilla*. Further, Verner and Wilson (1966) suggests that most of the birds that breed in marshy habitat are polygynous. In North America nearly 80 per cent of the birds that breed in marshes are polygynous. Verner (1964) and Crook (1962, 1963, 1964, 1965) suggest that polygyny evolves in productive habitats, with abundant vegetation and food. During the present study the fantail warblers were found to be polygamous.

In the present study the herons, egrets, bitterns, storks, rails, jacanas, lapwings, other plovers, sandpipers, stints, snipes, stilts, gulls, kingfishers (*Halcyon* sp.); jungle myna, bluethroats, warblers (*Cisticola* and *Acrocephalus* spp.), weaverbirds and red munias were found in the rice fields. Ali and Ripley (1968-1974) state that the birds of this group belong to marshy and reed swamp habitats.

Birds like brahmny kites are partial to well watered habits

(Ali and Ripley, 1968-1974), while marsh harriers are partial to reedy swamps (Hudec and Stastny, 1978). Male streaked fantail warblers (Udea, 1984) and weaverbirds (Ali and Ripley, 1968-1974) are polygynous.

On the other hand, rest of the birds namely, cattle egrets, blackwinged kites, falcons, owls, pigeons and doves, bee-eaters, larks and pipits (both take to short grass areas) shrike, common mynas, chats, sparrows and munias are known to inhabit open, grassland habitats (Ali and Ripley, 1968-1974).

The marsh land inhabiting birds predominate in plots from beginning till the early tillering of rice. After early tillering stage grassland inhabiting birds become common in rice fields. But when the crop comes to maturity a mixture of both these habitat birds like bitterns, rails, bluethroats, snipes, *Arcocephalus* warblers) could be seen.

Such delineation of birds inhabiting rice fields into different faunal groupings would go to further strengthen the views held by several authors on the origin and the original habitat or present day cultivated rice. Because, the idea that the rice fields are an extension of freshwater marshes (Odum, 1966) is strengthened by the ways the marshy habitat inhabiting birds have adapted to rice fields. Likewise, the grassland inhabiting birds find the standing rice fields as a stretch of grassland, during the later part of cropgrowth. Hence, it is arguable that rice annual grass (graminae) once grew abundantly in marshy conditions.

Even though rice cultivations are fairly recent habitats, continually changing in character under man's influence, these marshy and grassland

inhabitants could easily adopt themselves to these new rice habitat conditions which structurally at different stages, resembled their natural habitats.

As human civilization advances the grasslands, savanna and marsh habitats were among the first to be converted to agricultural lands (Weins, 1976; Chang, 1977) and the birds of these original habitats were in fact, 'pre-adapted' to colonize croplands (Weins, 1976).

5.2 Seasonality and Abundance of birds in rice fields

5.2.1 Seasonality

In south-east Asia, two distinct seasons namely wet and dry seasons exist mainly due to the seasonal monsoon cycle (Fogden, 1971). In Bangalore, the wet and dry seasons (Murthy, 1975; late May-October and February-May, respectively) are interspersed by a mild winter.

5.2.1.1 Migrants

Birds that frequent rice fields show a considerable seasonality with respect to these changes. Marked seasonal movements were seen in North-Indian (including local migrants) and palaeartic migrants (a total of 28 species), chiefly between September and April (Ali and Ripley, 1968-74).

The results of the present study also indicated a similar pattern of September-April movements of 28 species (Appendix-IIa; Fig. 6a, b, c). But, most of these species differ from this trend with respect to their

activity in rice fields. Based on their activity the migrants can be grouped into following categories.

a) Strongly seasonal migrants

Among the migrants, eight species (marsh harrier, snipe (*Capella* sp.) common swallow, brown shrike, yellow and grey wagtails) can be considered to be strongly seasonal as their activity was independent of the effects caused by varying field conditions brought about by cultivation practices and growth of rice crop. They are present from September-October to next April (Fig.8, 9, 10). The bluethroats and paddyfield warblers were seen from November to next April (Fig.8, 9, 10) and were absent even when standing paddy crop was present. However, at KGH and NGR the wagtails were less frequently seen and the grey wagtails arrived earlier than yellow wagtails.

b) Visitors during preparatory cultivation and open field conditions

The activity periods of brownheaded gull, little ringed plover, green sandpiper, spotted sandpiper, common sandpiper, little stint and blackwinged stilt, coincided with the preparatory cultivations after November, December and subsequent availability of transplanted fields. The peak populations of these species was seen between January and April. In otherwords, the availability of suitable field conditions limited the activity of these species in rice fields.

c) Irregular migrants

Eleven species of migrants (pale harrier, baillon's crake, greyheaded

lapwing, golden plover, marsh sandpiper, temminck stint, pheasant-tailed jacana, wiretailed swallow, rosy pastor, blyth's and great reed warblers) were either in very low numbers, or were sighted on a very few occasions (Appendix-V) to predict any discernable trend. The reasons for this as discussed earlier in section 5.1.2 might be due to their nondependence on rice fields. The other reason might be due to their distributional peculiarities (Straggler- e.g. greyheaded lapwing) or the species in being a passage migrant (e.g. baillon's crane).

The rosy pastor's activity in Bangalore coincides with the fruiting of *Ficus mysorensis* Heyne ex Roth and *F. benghalensis* L. during February-April (personal observations). The rosy pastor flocks seen twice at HBL could have been a part of it.

The painted snipe appears to migrate locally after breeding elsewhere during June-August. The species is known to nest frequently in rice fields (Ali and Ripley, 1968-74). In Tamil Nadu the species is known to breed from September to next April (Wesley, 1984). The birds were usually observed in the study areas during May-June-August months.

Thus, the mere seasonal migratory influx of most of the migratory species do not result in an increased activity in rice fields. Instead their seasonal migratory influx in rice fields is disrupted by the availability of suitable field conditions in the cases of several species while for others rice fields do not appear to be one of the principal habitats. Karr (1976) indicated that seasonal irregularities of migrants are correlated with resource seasonality and irregularities in physical environment.

5.2.1.2 Residents

The seasonal breeding cycle and the prevailing cultivation practices (both preparatory cultivations and harvesting), during the two growing seasons seems to affect the activity of resident bird species in rice fields.

Several resident species (pond heron, brahminy kite, white-breasted kingfisher, common myna, jungle myna and house crow) were invariably found throughout the study periods (at least at HBL), but their peak population levels coincide with preparatory cultivations (June-August-September and January-March) and harvesting (May-July-August and December-January) (Table 5, 6, 7, 9, 10 and 11).

Pond herons usually foraged in plots that were freshly harvested and prepared for subsequent transplanting. Brahminy kites were most numerous during December-January harvestings and May, June-August preparatory cultivations and December-January harvesting operations (Table 10). However, at NGR these kites were active even during January-March preparatory cultivations. The reasons for this difference could not be attributed to any reasons. Similarly, crows and mynas were abundant in periods similar to the brahminy kites and the relatively low numbers of these species during January-March periods appear to coincide with their breeding cycle (Ali and Ripley, 1968-74). Hence, they were less abundant.

The continued activity of certain resident species get disrupted by their seasonal breeding cycle. Baya weaver-birds, munias, cattle

and little egrets were most abundant in rice fields during their non-breeding seasons (Fig. 8, 9, 10).

Being monsoon nesters, cattle and little egrets' nesting activity began from May-June onwards (Ali and Ripley, 1968; Sharatchandra, 1979). As a result little egrets were in low numbers at HBL, but their activity increased from October (for little egrets) and December (for cattle egrets) onwards, and extended till the next April. They usually increased their activity during preparatory cultivations from January-March.

The bayas and munias (excluding red munias) start their nesting activity after the onset of monsoon. (Ali and Ripley, 1968-74). Hence, they were most abundant from February to August with the peaks towards March-July. They disperse for breeding with the onset of monsoon after June. In spite of such marked nesting seasonality, low populations of these birds could be seen in the study areas even during nesting seasons. Bayas had a regular breeding colony at HBL both during 1982 and 1983. Red munias breeding activity differed from other species of minias and were absent from study areas (except for the nesting birds at HBL) from October to February, when nesting occurred.

Increased activity of larks and pipits, bluebreasted banded rail and whitebreasted waterhen was seen only when suitable conditions for nesting within the study areas were available. Thus the activity of larks, and pipits, being dry season nesters (Ali, 1968-1974; Ali, 1979) was limited by the availability of uncultivated dry plots (March-June). Pipits unlike larks were active even outside their breeding season i.e.,

from October or December to February when dry plots were available (as at HBL), but nested only during summer.

the above two rails that nest in rice fields were active from May, June to August, September (as at HBL) and were absent from January till nest monsoon. Two of the resident species namely the streaked fantail warbler and Indian wren-warbler were found more or less throughout the study period but their peak populations coincided with the availability of standing crop of rice after late tillering stage. Hence, they were abundant from March, April to July, August and again from October to next January. Asynchrony among plots with standing crop at HBL permitted continued existence of these two species with their population touching a minimum during the beginning of dry period when most of the area was under preparatory cultivation. Similar observations were made on the streaked fantail warbler by Avery ((1982) in Malaysia.

The roseringed parakeet showed a certain degree of seasonality during the study period. At NGR and KGH areas the parakeets activity from May, June-August coincided with harvesting of summer crop and seeding of rice nurseries. At HBL they were irregularly seen during October, November and January-February was to feed on standing rice crop and in freshly harvested plots. The reason for such a variation in parakeets activity between the study areas could not be identified.

The activity of blue rock pigeon, Indian roller, and redwattled lapwings were markedly dependent on the availability of dry open field

conditions for feeding. Thus the pigeons were active only after the crop was cut (November, January, June to August) the rollers were seen irregularly during dry periods (December, January-May, June) mostly at KGH. The redwattled lapwings were seen only in open habitats (harvested plots and plot conditions before early tillering stage (June, July-August, September and December-March).

The activity of other species (little green heron, chestnut bittern, median egret, openbilled stork, blackwinged kite, shikra, redheaded merlin, ruddy crake, kora, yellow-wattled lapwing, spotted dove, plaintive cuckoo, house swift, palmswift, small green bee-eater, hoopoe, redumped swallow, black drongo, jungle crow, whiteheaded babbler, ashy wren-warbler, tailor bird, pied bush chat, and streaked weaverbird) could be termed as irregular or erratic as these species were either seen less frequently or were too low in number discern any activity pattern.

5.2.2 Abundance

Rice field bird species show a great variation with respect to their abundance and commonness. It appears that rice fields like any tropical habitat (e.g. forests) (Karr, 1976) are marked by a large number of rare species, several species with low populations and relatively few species being highly common or with large population sizes. The analysis of the frequency of occurrences and population sizes (Appendix-V) indicates the patterns similar to the opinion expressed by Karr (1976).

at HBL area the most common species were the pond herons, brahminy kites, whitebreasted kingfishers, streaked, fantail and Indian

wren warblers. All these species were resident species having recorded on over 100 censuses out of 162. The availability of food or/and nesting cover seems to be the main reason for such frequent occurrence of these species. However the most abundant species being the spotted munia (with flock size 660 birds) followed by baya weaver bird, red munia, spotted sandpiper, whitebacked munia, roseringed parakeet and blackheaded munias (Appendix - V).

Most of these species except the migrant sandpiper, were pest of rice, while the birds of intermediate abundance were jungle myna, cattle egret, blackwinged stilt, bluerock pigeon, little stint, pond heron and streaked fantail warbler (maximum population range 50-130 individuals). Twenty one least abundant species were represented by less than four individual (Appendix - V). These included 16 species that were seen less than three times and could be termed rare at HBL (Appendix - IIIa; V).

At NGR the most common species seen on over 40 census (out of 78 census) were again the pond heron, streaked fantail warbler, brahminy kite, and Indian wren-warbler, while 21 species had a sighting frequency between 10 to 40. The most abundant species included yellow wagtail, spotted sandpiper, roseringed parakeet, house sparrow and common swallow (Appendix - V).

The least frequent species included little green heron, chestnut bittern, marsh sandpiper, wiretailed swallow, small blue kingfisher, ashy-crowned finch lark, wire-tailed swallow, brown shrike, black drongo,

piebush chat, grey wagtail, large piebush wagtail and whitebacked munia. These include nine species that were least common and were considered rare. Other species between these two extremes had varying commonness and abundance (Appendix - V).

At KGH again the pond heron, brahminy kite and streaked fantail warblers were the most frequently sighted species (over 50 out of 72 census). Nineteen other species had a sighting frequency between 10 and 50.

The least common species (seen on less than four census) were the pale harrier, openbilled stork, whitebreasted water hen, greyheaded lapwing, golden plover, spotted dove, streaked weaverbird, blackheaded munia, common sandpiper, plaintive cuckoo, painted snipe, little stint and house swift. The least abundant species were pale harrier, openbilled stork, greyheaded lapwing, golden plover, whitebreasted waterhen, common sandpiper, plaintive cuckoo, brown shrike and grey wagtails.

These pattern of commonness, rarity and varying abundances among bird species among the three study areas (in Appendix V) indicate that a number of species are rare in rice fields suggesting that they were 'floating species' whose occurrence could only be a matter of chance. Further, only a few species were found almost throughout the year in low populations, while others less frequent than these with a high flock sizes at certain periods. This pattern when coupled with the disruption of otherwise possible seasonal influences, by availability of suitable field conditions, and seasonal breeding habits, indicate opportu-

nistic exploitation of the available habitat conditions.

5.2.3. Bird species diversity in rice fields :

The changes in species diversity are mediated by changes in either of the two components, namely, richness and evenness (Tramer, 1969). In rice fields the changes in diversity as observed during the present study appears to have been mediated more by the richness component (Table 4).

Fluctuations in diversity show an increase during the migratory period (September - March) of birds (Fig. 8, 9, 10) due to migratory influx. This is particularly true in tropical habitats (Karr, 1976). Except for NGR, the diversity in the other two areas show a least dependence on evenness. This indicates that fluctuations in the population sizes of individual species may have been mediated by availability of suitable field conditions as the field conditions may have been suitable for only a few common species but the presence of a large number of rare species or irregular species may have contributed to their erratic fluctuations of evenness. As a result, diversity shows a high dependence on the richness component alone.

5.3 Food, Feeding habits and the activity pattern of certain bird pests:

5.3.1 Food and feeding habits :

The annual wet and dry cycles, coupled with different cultivation practices in rice fields, and aquatic vegetation including rice, form a

conducive environment for a great variety of metazoa including annelids, molluscs, spiders, crustacea, insects, frogs, snakes and squirrels (Heckman, 1979; Anon., 1976; Grist and Lever, 1979; Chatterjee and Dutta, 1979, 1980a, b; Battish and Grover, 1984; Patel *et al.*, 1955; Jordon, 1969; Ghapurley, 1947; Alam *et al.*, 1980). With such a diversified biota, rice fields, like grasslands and freshwater marshes (Verner, 1964; Cody, 1968; Welty, 1982) appear to be an extremely productive habitat in nature (Odum, 1963; Kendeigh, 1974; Avery, 1980). As the occurrence and abundance of such a varied biota is limited by seasonal climate and cultivation of rice crop (Heckman, 1979) rice fields represent a situation of highly variable or heterogeneous or dynamic habitat (Pianka, 1978). Pianka (1978) opines that such erratic environments, are usually occupied by species which are opportunistic in habit.

Among the 81 species of birds observed visiting rice fields 13 species were observed feeding on rice grain and as primary consumers.

Based on their feeding activity in rice fields, these 13 primary consumers can be categorised into major and minor pests of paddy. The former group includes in the order of importance. The spotted munia, baya weaver-bird roseringed parakeet and red munia. The minor pests are the whitebacked munia, blackheaded munia, house sparrows, whitethroated munia and the rails. The blue rock pigeon though a feeder on paddy grains, it cannot be labelled as pest as it feeds only on fallen grains on the ground after harvest. Since farmers are not interested in recovering these grains which have already been shed during harvest, and in effect, pigeons are not a constraint in realizing greater yields.

The same analogy can be applied to rose-ringed parakeet and white-throated munias, which also feed on fallen grains after harvest. The activity of spotted doves and whiteheaded babblers are too low to cause any concern as they also feed on grains fallen after harvest. The details of the feeding activity of bird pests namely baya weaverbirds and munias is dealt in detail under section 5.3.3

The pattern of feeding of granivorous birds during the present investigation indicate that with the non-availability of their natural food, birds switch over to feed on cultivated crops (Ward, 1965). Dyer and Ward (1977) opine that any such problems posed by birds are due to some change in the agro-ecology of an area, not necessarily due to change in bird behaviour. The belief that bird pests are attracted into region by the crops is not true. Rather, the crops have been introduced into an area already with a sizeable population of granivorous birds for which at times the cultivated grains may substitute for the wild seeds. Thus, the pestilence habits of weaverbirds and munias are more of a man made problem than a natural one.

The habit of the munias feeding on *Spirogyra* seems to be common (Woodall, 1975; Pillai, 1968; Avery, 1980). This is believed to be related to the birds' reproductive cycle, for *spirogyra* considered to meet the protein requirement of breeding munias (Avery, 1980).

Parakeets appear to be the most destructive of all the bird pests when one considers the nature of damage (Ali and Ripley, 1968-74). Though these birds were observed to be less frequent visitor to rice

fields, the birds could become serious pest, because of their large flocks, abundance and the habit of cutting the whole earhead. However, their infrequent visits to rice fields to feed on ripening grains or in nurseries or harvested field seem to indicate that these birds depend on a greater variety of alternate food sources (Simwat and Sidhu, 1973; Shivanarayana, 1982). Probably they switch to feeding on rice when alternate food is not available. If habitat destruction involving 'parakeet-preferred' food trees (Simwat and Sidhu, 1973; Shivanarayana, 1982) and plants continues, these parakeets might become the most destructive bird pests of rice in future.

The insectivorous warblers, especially the streaked fantail warblers and the Indian wren warblers appear to be yet another group of birds that are important predators of insects (Mason and Lefroy, 1912). Their value as predators of insects increase because of their nesting activities, as these birds show a certain degree of specificity with respect to the prey species fed to their young ones. A major portion of the diet of these birds made up of *Pelopedis mathias* and *Oxya fersovittata* which are major pests of rice. Hence, these birds are important in reducing the menace by these two species in rice fields, although there is no means to encourage and increase their populations in rice fields. Since the nesting activity of these birds depend completely on the availability of these birds depend completely on the availability of standing crop, it is difficult to sustain these birds in rice fields, without resorting to staggered cultivation of rice, in such a way that a sizable area of the field at any time of the year, would have standing crop of paddy. These staggered patches will help to retain the breeding population

of these species almost throughout the year, as observed by Avery (1980).

The food habits of pond herons, smaller and little egrets, red-wattled lapwings and spotted sandpipers recorded by Mukherjee (1969-76) indicates that these birds do not merely feed on soil-invertebrates as observed during the present study, but also consume a large number of insect species which are pests of rice.

Similarly, even the cattle egrets appear to be a very important predators of rice insect pests, as they consume much greater proportion of pest insects than the pond heron, other egrets, lapwings and sandpiper. Cattle egrets even though are predominantly ground foragers behave as foliage gleaners in the later stages when the rice field is covered with standing crop. Cattle egrets have been known for their association with grazing cattle in a grass covered ground. As the cattle walk forward, their moving hooves disturb the insects resting on grass. These insects make an easy prey for egrets which will be moving close to the legs of cattle (Heatwole, 1965; Dinsmore, 1973; Thompson et al., 1982). Cattle egrets employ this habit in rice fields when standing crop is available, but they substitute the effect of moving hooves of cattle, with their own movement through the standing crop. Their movement disturbs the insects harboured by rice plants and the cattle egrets pick up insects that are flushed. Hence, these ground foraging birds merit serious consideration (Mason and Lefroy, 1912; Mathew et al., 1978; Thirumurthy et al., 1981; Nathan and Rajendra, 1982).

Other important insectivores were the black drongos and bee-eaters (Mason and Lefroy, 1913; Mukherjee, 1969 and Mathew, 1978). They were seen in very low numbers. When one considers their feeding behaviour, it is evident that these birds depend on suitable perches for foraging. Providing suitable perches in the form of stakes at the middle or edge of each plot in rice fields may result in greater activity of these birds. Such elevated perches would also aid in increased activity of whitebreasted kingfisher which also need perches for scanning the ground below, along the edges of field or close to irrigation nals for capturing crabs.

Shift in feeding sites was seen in case of pond herons, brahminy kites and whitebreasted kingfisher.

Methods similar to those used by brahminy kites has been recorded by Bessinger (1983) in case of snail kites (*Rostrhamus sociabilis*) in the rice fields of Guyana. The first method described as 'course hunting' (Bessinger, 1983) involves greater searching and the brahminy kites resort to this energy consuming method as the availability of crabs, in open fields without any crop, during preparatory cultivations and harvesting is greater. As the fields are covered with standing crop, crab availability decrease and exposed field edges will be the only place where the kites can prey upon crabs that stray out. During this period the kites used the second method referred to as 'still-hunting'. Foraging kites are known to adopt energy expensive foraging methods when prey availability is greater and resort to less energy consuming foraging method

when prey availability goes down (Bessinger, 1983), hence brahminy kites 'still-hunt' along field edges when the area is covered fully with crop. Hence the seasonal variations in crab capture in different field types is based mostly on the availability of prey due to changing field conditions than seasonality in behaviour. Further, these kites appear to supplement their diet by preying on dragonflies when crabs are poorly available.

Similar changes in feeding behaviour was seen in pond herons which shifted their feeding sites from open field to field edges once rice crop covered the area. These birds that once actively moved inside open fields resorted to waiting motionless with their beak held motionless for capturing prey that might come close (Ali and Ripley, 1968-74), along the field edges.

Whitebreasted kingfisher's captured crabs from cropped field edges and nalas when open field conditions were not available.

Such shifts in foraging strategies appear to be prevalent among birds, due to changing conditions (Diamond, 1974). Further, such changes may indicate the greater adaptability and plasticity of behaviour of the species concerned (Glue, 1971; Blake, 1982).

The nocturnal activity of spotted owlets and their habit of capturing air-borne insects close to canopy level indicate that these birds could be feeding on certain moths (eg. pyralids) which are active after dusks (Ayyar, 1940).

Based on the different trophic levels of birds in rice fields, several types of avian foraging guilds can be identified (Appendix - IIIa). These guilds are : ground foraging guilds (including herons, egrets, storks, rails, plovers, sandpipers, stints, snipes, stilts, jacanas, hoopoe, parakeets, doves, pigeons, babblers, larks, pipits, mynas, crows, chats, bluetheats and wagtails); foliage gleaners, (warblers, baya and streaked weaverbirds); earhead gleaners (parakeets, sparrows, munias and weaverbirds), salliers (bee-eaters and drongoes), perch-to-site forages (whitebreasted kingfishers, shikra, brown shrike, pied bush chats) and the hawking guild (swifts, swallows, merlins, kites, harriers).

Such a high diversity of rice field birds is associated with an equally high diversity of prey (Appendix - V; Heckman, 1979). These birds interact among themselves to feed on this diverse biota forming several food chains (e.g. rice grain - weaver bird/munia - Falcon; insects-warblers-rodent-kite/falcon; crabs-kingfishers/myna-crow/egret-Harrier/falcon; soil-invertebrate-waders-Harrier/kite; grain-rodent-kite etc.). These food chains are interlinked to form a complex food web. Such a complex food web is an indication of a high species diversity (Paine, 1966) prevalent in rice fields.

Further, the guilds are so structured that their foraging or exploitation of resources is heavily dependent upon resource availability (Holmes, et al., 1979). This availability of different prey in rice fields (soil-invertebrates, aquatic, pest and nonpest insects, airborne insects and rice grain) is again dependent on the availability of suitable field conditions

before or after transplanting of rice crop. For example, pond herons, egrets, crows, mynas and brahminy kites are attracted to plots under preparatory cultivations to feed on soil invertebrates exposed during the operations, and the foliage gleaners should wait till the crop reached mid or late tillering stage for them to feed on insects and spiders, within the cover of standing paddy.

The response of birds' (egrets, mynas, crows and brahminy kites) to preparatory cultivation (Fig. 16, 17, 18) and harvesting (Fig. 19) is similar to the numerical response explained by Solomon (1949) wherein birds already present in the immediate vicinity of 'prey (food) rich areas' would arrive and begin to maximize their prey intake. Later, on seeing the foraging individuals, birds from neighbouring areas get attracted to the prey rich area (Wiens, 1976) (i.e. the plot under preparatory cultivation or harvest), thereby creating a 'local enchantment' (Hinde, 1969). During such local enchantments, the density of predators from what once been a meagre number of birds increases into a large feeding flocks (Wiens, 1969). The response of birds as depicted in Fig.10, 11 and 12 depicts a similar pattern among the above species. Such feeding by local enchantment has been observed in a large number of granivorous species (Hamilton and Gilbert, 1969; Newton, 1972).

The directional overhead flow of birds during the preparatory and harvesting among birds is otherwise referred to as 'roller feeding' appears to be characteristic of granivorous flock feeding birds (Ward, 1965 and Cody, 1971).

Wiens (1976) indicates that such feeding behaviour (i.e. local enchantment and roller feeding) appears to be characteristic of flock feeders which exploit patchily distributed prey. When the plot is being prepared (ploughed, puddled or levelled), the prey supply is continuously held at a maximum and renewed, as long as the plough keeps exposing the hidden soil invertebrates and as a consequence, the number of birds attracted will be on the increase. But no sooner the operation is stopped due to lack of renewal of prey or low prey availability the bird number declines rapidly (Fig. 16, 17, 18). Royama (1970) and Krebs *et al.* (1974) indicate that a predator's foraging activity continues as long as the energy yield/energy expended in foraging is high. Once the 'patch profitability' drops below a certain limit (low capture rate/unit search time) the predator 'gives up' its use of that patch. In rice fields this situation happens when the operation (preparatory cultivation or harvesting) is stopped and immediately, the birds start abandoning the plot. The bird numbers again increases when the operation is started as the prey availability once again increases.

As a result of such availability dependent foraging all the birds that frequent rice fields can be termed as opportunistic (Pianka, 1978) species. Such opportunistic habits of rice field birds further evidenced by the varied type of prey or food item consumed Appendix - VI) (Mason and Lefroy, 1912; Mukherjee, 1963-1973; Mathew *et al.*, 1978) by each of the birds recorded during the study. Hutchinson (1951) indicates that the species which take to newly disturbed sites, have a high dispersal ability and by this virtue they can colonize habitats which are unpredictable in nature (Pianka, 1978).

5.3.2 Flocking in birds of rice fields :

The feeding habits of bird pests of paddy namely, parakeets, sparrows, weaverbirds and munias indicate flock feeding to be a characteristic feature with these species. Lack (1954) considers that small passerine species, often feed in flocks. According to Wiens and Dyer (1977) the food consumption of many granivorous bird species appears to be associated with flock feeding.

The main advantage of such flocking is an increased awareness to avian predators. A bird feeding solitarily has to apportion the time available to it between looking out for predators, feeding and other essential activities or in other words, alternatively it has to spend relatively more time on vigilance and less time for feeding and resting (Lack, 1954).

The chances that an approaching predator will be noticed are much greater by a flock than by a solitary bird. Since at any given time, in a flock, more than one bird will be on the look out for predators, who would thus be able to detect and warn the flock members. Thus, an individual in a flock can devote more time for feeding (Lack, 1968).

Often, birds of prey (hawks and falcons) specialize to feed on solitary birds (Bent, 1938; Murton, 1968) or a bird flying behind a flock (Brown and Amadon, 1975; Subramanya, 1985). During the present study, the bayas captured by the redheaded merlins were solitary individuals and merlins were not seen attacking

flocks. Even the other non pest species either attacked or captured by merlins were always solitary individuals.

Once a predator is discovered, the birds fly in a tight flock, rapidly, and this prevents any bird of prey to single out an individual to strike. Tinbergen (1951), for example, describes a perigrine falcon (*Falco perigrinus* L.) stooping at a flock of starlings and trying to separate one individual before attacking. The compactness of the flock apparently prevented the perigrine stooping straight into the flock because of the risk of collision. Hence, it is suggestive that compact feeding flocks reduce the risk of predation (Goss-Custard, 1970). By associating with a flock of conspecifics or mixed species, an individual gains considerable immunity from possible predation (Lack, 1968).

Feeding in mixed species flocks of birds appears to confer greater advantage to any bird. The different colour patterns and sizes and the habit of continuous intermixing of individuals of different species in a flock during flight result in a 'confusion effect'. This makes it impossible for any bird of prey to concentrate on a single bird in a flock and capture it (Wing, 1956).

Thus, the above explanations appears to be the reasons as to why the bird pests of paddy show a tendency to feed in either pure or mixed species flocks (Table - 15).

Flocking habit in birds is also thought to enhance the ability of individual birds to locate scattered patches of food. Hence, birds

often get attracted to food abundant patches by such a behaviour is evident with house crows and common mynas and brahminy kites during preparatory cultivations and harvesting. As a result to this behaviour of a flock of few birds may swell into a large flock in a matter of minutes. Such feeding by local enchantment (Hindae, 1961) has been observed in several granivorous birds (Ward, 1965; Cody, 1971). Further, the directional pattern of movement of birds (e.g. crows and mynas) (Wiens and Johnston, 1977; Ward, 1975) is thought to optimize foraging and maximize net energy gain by foraging birds (Cody, 1971, 1974), as already foraged areas are not re-visited again.

5.3.3 Activity pattern of bird pests :

The high activity of these finch pests at HBL appears to be influenced by three major factors namely, seasonality, habitat suitability and predation pressure (Fig. 31).

Seasonality :

Seasonality is effected by two seasonal cycles that occur due to changing weather conditions in Bangalore (Fig. 2). The two seasonal cycles are the seasonal reproduction of birds and the cycle relating to the growth of grasses due to monsoon effect.

The breeding season of bird pests (finches) commences with or just before the onset of monsoon (Ali, 1980; Ali and Ripley, 1968-74) and continues upto January in some species. Most of these species

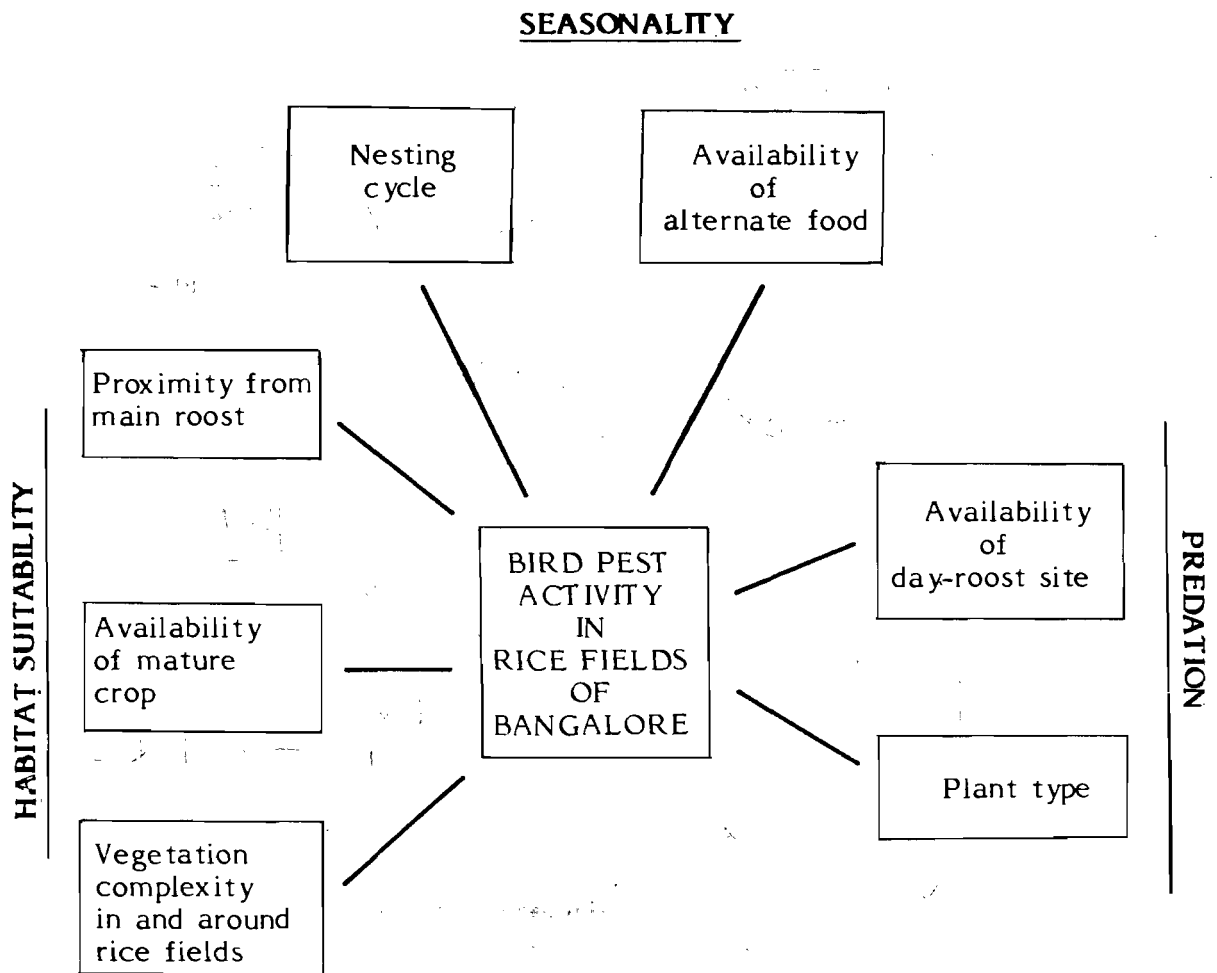


Fig. - 31: Bird Pest Activity Model for rice fields of Bangalore

being monogamous with the exception of baya weaver (Ali and Ripley, 1968-1974), spread out over the surrounding countryside, gardens and such other areas that can afford suitable nesting sites, and due to monogamous mating system (in species of finches other than baya) the flock feeding habit is less prevalent in nesting season and hence a flock once quite large, break up for feeding. The presence of bayas depends on the availability of suitable tree for building their hanging nest. At HBL coconut palms along the edges of the study areas met the nesting requirements of bayas.

With the advent of premonsoon and monsoon showers another cycle is set in motion. The grass seeds present on the dry ground under debris start germinating and by July-August put forth earheads with mature grains. The granivore finches start to feed on these grass seeds. Growth of these grasses and maturity of grain shows a second peak as seen during both the years of study period, due to north-east monsoon effects during November-December. During the intervening period (August-October) the birds feed on ripening jowar and bajra.

Grass seeds and millets from the natural food for finches (Naude, 1955; Lourens, 1955; Ward, 1965). As a result of this habit coupled with the nesting cycles, the finch pests occur in very low numbers to feed on monsoon-winter rice crop and this crop escape possible damage by these bird pests. The grasses due to their early grain shedding habit, shed the grains on the ground which under the debris would become unavailable to pest species after those exposed grains on the ground

have been eaten. Once these fallen grains of grasses become inaccessible or unavailable the birds revert back to feed on rice. This coincides with the grain filling and maturity of summer transplanted rice. The details of these seasonal cycles is depicted in Fig. 32.

With the beginning of summer, these birds start to regroup forming post-breeding congregation and these post breeding flocks begin again to roost as mixed species flocks (Gadgil and Ali, 1980; Ali and Repley, 1974; Dhindsa and Toor, 1980) and start to raid the crops. It is because of such seasonal influences, the finch pests observed during the study period at HBL did not show a proportional increase in abundance with increase in the area under mature crop (Fig. 27). Dyer *et al.* (1977) opine that granivorous birds usually start to congregate into large flocks throughout the summer and feed in agricultural fields containing ripening barley, wheat and grain sorghum. Such concentrations have rarely been observed to range more than one to two kilometers from their roosting sites (Gersdosf, 1955; Speyer, 1956; Summers-Smith, 1956 Fallet, 1958) Such postbreeding congregations of red-winged blackbirds are known to inflict severe damage to corn and rice in United States (Wiens and Dyer, 1975; Wiens and Johnston, 1977). Thus, the pestilence activity of bayas and munias in Bangalore restricted to crops that mature from mid to late summer season at HBL where the bird pests were found in great numbers compared to other two areas.

In Senegal, around lake Chad area, Ward (1965) has observed a similar cycle, but it is more pronounced in nature with the breeding

CYCLES

Rice crop

Monsoon

Nesting

Millet crop

Wild grass

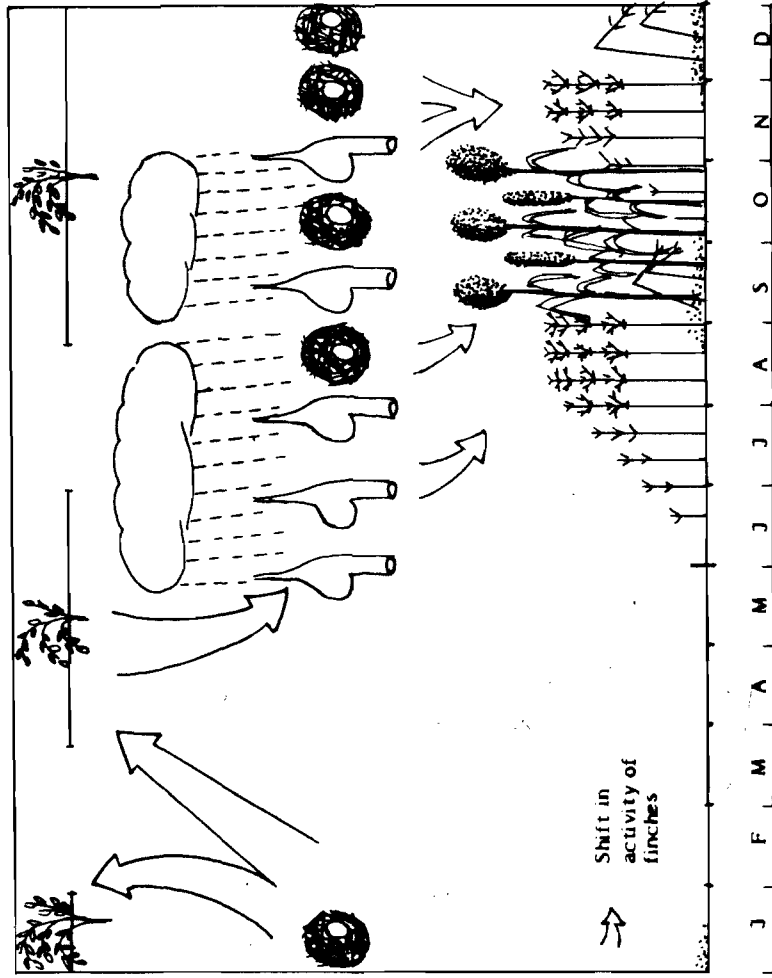


Fig. 32. Certain seasonal cycles associated with the activity of bayas and munias

habits of *Quelea quelea*. In these areas, quelea feed upon ripening grain of annual grasses (e.g. *Panicum* spp. *Echinochloa* spp. during breeding season and continue to feed upon the fallen seed from these plants covering the ground during the dry season. With the coming rainy season, the remaining seeds become inaccessible to the birds, forcing dietary shifts, and when annual grass grain are not available the birds turn to cultivated crops (Ward, 1965; Katz, 1974).

Habitat suitability

The finch pests showed a greater preference to frequent and feed at HBL than the other two areas (Fig.1b) indicating HBL was the most preferred area than the other two study areas. The seasonal abundance curves show the order of preference of study areas to be HBL, NGR and KGH (Fig.1a). The same order is maintained when one considers the distance of the three study areas from the main roosts for the finch pest species. The HBL was the closest in terms of proximity (0.75 km) and KGH (2.0 km) the farthest from the main roost (Fig.1, Table - 1)

Weins and Dyer (1975) also found that greater concentration of bird pests decreased as the distance from the roost epicenter increased mainly because, as the prime food sources become located increasingly farther from the roost site. It requires longer flight to reach them. As a result, consumption of corn by blackbirds is greatest in areas close to roost. Studies on corn damage by redwinged blackbirds (*A.phoeniceus*)

have shown that almost all the crop fields that were located close to the main roost of blackbirds were severely damaged (Dyer, 1967; Dolbeer, 1980).

Flights to crop fields at increasing distances away from the main roost not only increase the energy expenditure which the bird must balance by consumption, but also reduces the time available for foraging and meeting these increased demands. There comes a point at which the bird can no longer maintain an energy balance by flying greater distances to food sources. When this occurs, the birds may be expected either to confine their attention to less preferred food resources closer to the roost site (Wiens and Dyer, 1975).

This situation probably applies to the habit of bird pests preferring HBL, which happens to be the closest to the main roost.

Further, habitat structure is known to influence the composition and diversity of avian communities (MacArthur and MacArthur, 1956; Wiens, 1969; Anderson and Shugart, 1974; Whitmore, 1977; Yahner, 1983). The number of bird species increase with complexity of vegetation structure, specifically with the vegetation and foliage height diversities (Emlen, 1972; Anderson et al, 1983).

Hence, it is quite reasonable to consider that the greater vegetation diversity and complexity at HBL (Fig.2; Table-I; Appendix-III) has attracted greater concentrations/numbers of bird pests than the

other two areas. Often it is viewed that in addition to providing foraging niches (Mac Aurther, 1958) and sites for nesting (e.g. Yahner, 1982) vegetation stands also offer cover (or shelter) from predators (Kendeigh, 1974; Pulliam and Mills, 1977; Welty, 1975). Even though KGH had a tree line, it failed to attract sufficient number of finch pests as by location it was farthest from the main roost and also had less complex vegetation than HBL. Nagavara attracted more finch pests than KGH mainly because of its greater proximity to roost site (Fig.1; Table-1; Appendix-1). However, it failed to attract as many finches compared to HBL as it had an extremely low complex vegetation.

The importance of complex 'non-rice' vegetation becomes more apparent when we consider the lack of any correlation between the abundance of bird pests and the extent of HBL under mature crop (Fig.27).

Within HBL area, the distribution of feeding birds was neither random or uniform but highly concentrated in space mainly due to the tendency of bayas and munias (excluding red munias) to feed closer to the cover of tree line or sugarcane or sunflower stands (Fig.25). This behavioural pattern resulted in the concentration of feeding activity of birds about the periphery of the field or close to cover. As a result, the bird damage to paddyfield was localized and the entire field was not affected.

Such localized nature of damage to crops appears to be characteristics of bird pests. The redwinged blackbirds in United States aggregate during non-breeding season and feed locally in concentrated flocks (Weins and Dyer, 1977). Their damage to corn was generally localized and confined to relatively few areas. As a consequence many fields were untouched and a few severely damaged. The economic loss was thus great for relatively few farmers as nearly 88-91 per cent of the fields surveyed by them suffered no damage at all (Dyer, 1967; Stone and Mott, 1977). A similar view about the damage pattern of *Quelea* is shared by Ward (1968). Several species of sparrows (*passer domesticus* (L.), *P. montanus* (L) and *P. hispaniolensis* (Temminck)) cause considerable damage to fields of ripening wheat, barley and other grain in close proximity to the nesting colonies or shrubs and trees in which the sparrows find shelter (Weins and Dyer, 1977). When these birds associate with biotope edges, and the margins of fields attacked by sparrows generally suffer more damage than the middle parts (Kashkarov et al, 1926; Akhmedov, 1949; Keleinikov, 1953; Dawson, 1970; Havlin, 1974).

Dependence on such vegetation for roosting during day or for use as cover is quite common among finches. large flocks of spotted munias roosting in lantana (*lantana camara*) thickets close to paddy fields (Warth, 1953); bayas roosting in nearby mango orchards and beetle vine gardens in paddy growing areas of Andhra Pradesh (Mathew, 1975); munias in sugarcane and bamboo thickets (Saha and Mukherjee, 1978); New world sparrows (Emberizinae) foraging close to trees or bushes (Pulliom and

Mills, 1977) and sparrows in a freshly sown fields feeding close to hedgerows (Barnard, 1980). Ward and Zahavi (1973) refer to such diurnal resting centres within the feeding area "day roosts" or "secondary roosts". These day roost sites are known to be used throughout the day especially during the hot hours.

Wiens (1969) and Cody (1968) have thoroughly analysed the habitats of North American sparrows and found interesting correlations between habitat structure and sparrow populations. In a study, Davis (1967) observed that three species of towhees' foraging was highly influenced by the availability of cover. The spotted towhees (*Pipilo erythrophthalmus maculatus*) foraged below the cover, brown towhees in open near cover and Abert's towhee (*P.aberti*) foraged at intermediate distance from cover. Johnston and Odum (1956) argue that grasshopper sparrows are dependent on cover to the extent that they disappear from fields with less than 35 per cent shrub cover.

Predation

The reason for such a cover dependent foraging (Fig.25) appears to reduce the risk of predation. Finches like sparrows, weaverbirds and munias are included in the diets of several species of diurnal predatory birds, like hawks and falcons (e.g. New world sparrows by Cooper's Hawk (*Accipiter cooperi*), the prairie falcon (*Falco mexicanus*), the american kestrel (*Falco sparverius*) (Pulliam and Mills, 1977); sparrowhawks (*Accipiter nisus*) and kestrel (*F.tinnunculus*) capturing house sparrows (*P.domesticus* Barnard, 1980); red headed merlins feeding on house

sparrows (Subramanya, 1985) and the food of redheaded merlins Appendix during present investigation.

Most of these predatory birds rely on swift flight and surprise attack to capture birds (Rudebeck, 1950, 1951; Morse, 1973; Subramanya, 1985) and in most cases avian prey are taken on ground or in flight (Bent, 1938; Pullian and Mills, 1977; Subramanya, 1985). Thus for an avian prey, cover is a relatively safe place, but reaching the safety of this cover when they forage far away may be hazardous (Pulliam and Mills, 1977). Most predatory birds can fly faster than small birds, and as the distance from cover increases the chances of birds like finches reaching it safely decreases, as the birds of prey can outfly these smaller prey can capture them before they reach cover. Foraging near trees or any dense vegetation stands and in early detection of a predator allows the weaverbirds and munias sufficient time to get to cover.

Thus, when food is available closer to cover Munias and weaverbirds tend to restrict their foraging distance as close to cover (< 10 m) resulting in the localized nature of damage to rice.

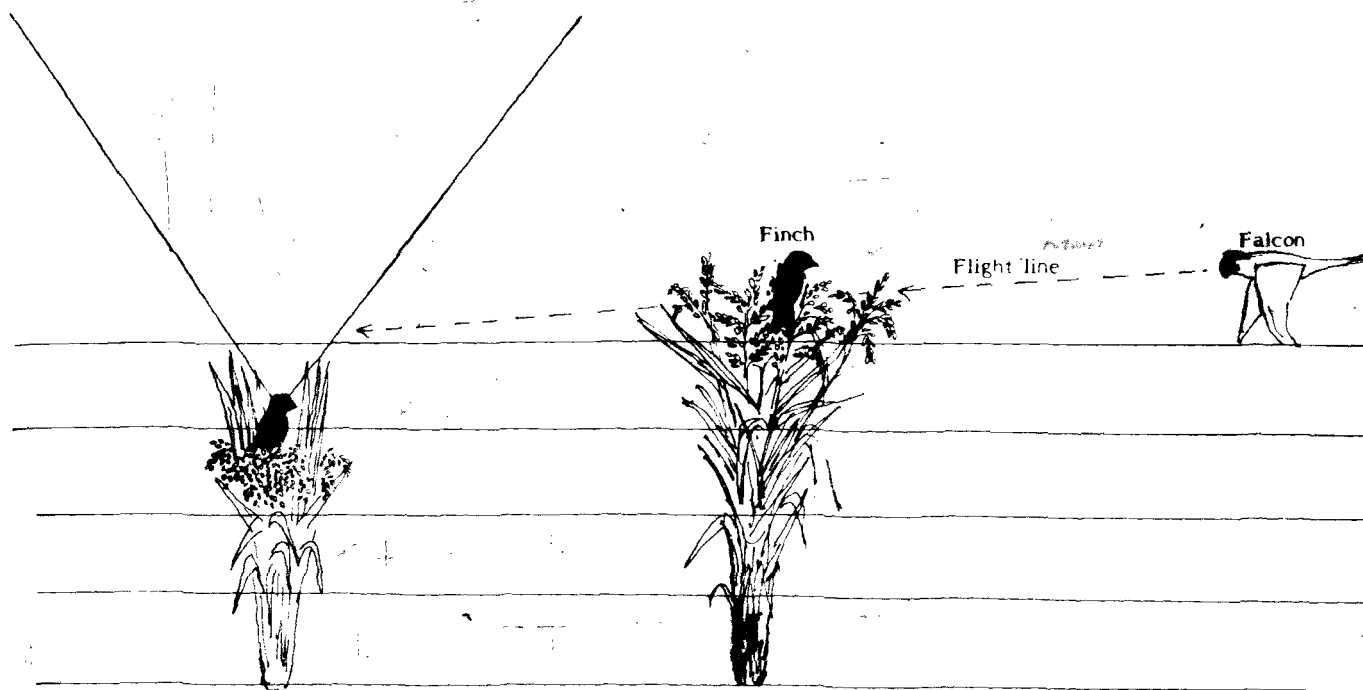
Further the birds' choice to feed on certain paddy varieties (Table- 30), as seen in a field trial, is again appears to be cued towards reducing the risk of predation. By feeding on a tall variety (Type-I) with an erect exposed (due to oblique flagleaf) earhead (Table-32) the bird pests will have an unrestricted view of their surroundings and hence they can detect the approach of a predator early and fly to the safety

of cover. On the other hand, if these birds were to feed on dwarf varieties (Type-II) with drooping earheads and the erect flagleaves projecting above the earhead, the risk of being captured by a predator could be quite high. The reason being, the flagleaf shields the vision of a bird that often has to bend down or feed up-side-down to on grains from drooping earheads. As a consequence the time spent on predator vigilance would increase and the same on feeding decreases.

The study by Metcalf (1984a) shows that presence of objects adjacent to feeding shore birds reduced their visibility and as a result the time spent on anti-predator vigilance increased.

Similarly, the erect flagleaves surrounding the bent earheads in Type II varieties curtail the field of vision and hence appear to increase the risks of predation to feeding birds. Because of this reason Type-II varieties appears to have not preferred by feeding bayas and munias (Fig.33)

Reduced preference of varieties with erect flagleaf in rice by baya weaverbirds and munias (Raju and Shivanarayan, 1980); bent 'goose neck' type of earheads in sorghum and Queleas (Doggett, 1953); varieties of maize with cobs borne at a lower level on the plant and placed in horizontal position, being more vulnerable to attack by redwinged blackbirds (Weatherhead and Tinker, 1983) and parakeets and crow (Bhatnagar et al, 1982) seem to support the present hypothesis in the light that the structural variations of normal plant types and earhead characteristics



TYPE II Plant

- * restricted field of vision
- * late-detection of an approaching avian predator.

TYPE I Plant

- * unrestricted field of vision
- * early detection of an approaching avian predator.

Fig. 33. Possible influence of rice plant types on the field of vision and predator detection in feeding finches.

deter bird pests from feeding as the feeding bird has to (a) occupy a position that would curtail its field of vision and it will be less efficient in early detection of the approach of a predator (b) invest more time for vigilance and thus probably reducing the net time devoted for feeding. (Fig. 33).

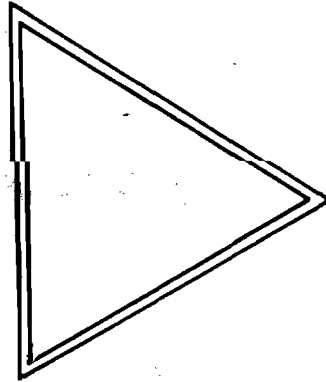
Hence, it appears that bird pests tend to avoid such varieties (Table-25, Fig.34) that would negate the anti-predatory advantage gained by flocking habit.

Metcalf (1984a, 1984b) has shown that the time spent on vigilance by feeding birds' depend on the neighbours that they can see in a feeding flocks, and in effect, the fellow group numbers 'share' vigilance (Pulliam, 1973; Diamona and Lazarus, 1974; Treisman, 1975a, b, Pulliam et al., 1982). Since they monitor the vigilance of their neighbours they can only see a bird which cannot see its neighbours tend to be more vigilant. The effect of erect and projecting flagleaf above the earheads in rice or low placement of cobs on plant with a stand of maize seem to bring about the same effect in the sense that it not only curtail the field of vision of a feeding bird for predator scanning, but also hides its feeding partners from its vision. The net effect is a greatly reduced safety for a bird feeding bird.

In contrast to Bayas and other munias, the red munias show a tendency to feed in pure flocks and a different habit of flying up and circling over the cropped area in a tight flock and dropping back

**Plant characters associated
with increased preferences.**

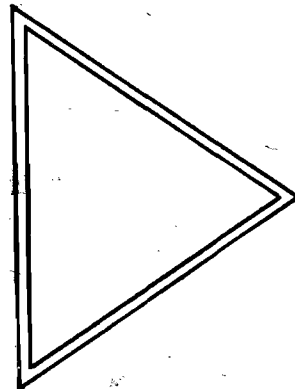
1. Tall stature
2. Wide plant spread
3. Erect earhead
4. Oblique flagleaf
5. Flagleaf below earhead



**Less
predation
risk**

**Plant characters associated
with decreased preference**

1. Dwarf stature
2. Compact plant spread
3. Drooping earhead
4. Erect flagleaf
5. Flagleaf projecting above earhead



**High
predation
risk**

Fig. 34. Plant characters associated with possible risk of predations

among standing paddy later. Such solitary predation evasion strategy is adaptive in areas of dense grass (Pulliam and Mills, 1977) and is well illustrated in grasshopper sparrows (*Ammodramus savannarum ammodramus*) and chestnut-collared longspur (*Calcarius ornatus*). These North American sparrows inhabit open grasslands with scattered trees and such a behaviour is considered to be adaptive (Pulliam and Mills, 1977).

Besides this, their sexual dimorphism in colour (Male red munias are bright red in colour and females are drab brown (Ali and Ripley, 1968-74) pure flocks of red munias (Table 15) may have the same 'confusion effect' that is thought to prevail in mixed flocks with species of varied colour pattern. The tight knit flock during flying is another adaptive strategy to prevent a predator from concentrating on a single individual or make a dash into the flock to capture a bird (Wind, 1956).

5.3.4. Implications for management of bird pests in rice fields.

The observations made during the present study period clearly indicate that the proximity of the rice fields to the main roost and the vegetational complexity in and around the rice fields influence the occurrence and abundance of bird pests. When such fields (e.g. as in Hebbal area) come within the birds movement range, they are readily invaded.

Under such situations, the simplest method of management of bird pests would be to modify the habitat i.e. the preferred rice field. Habitat manipulation involves the removal of those features

(other than the crop) from the habitat, which attract the birds to the crop field (Wright, 1968).

Thus, a total destruction of the stand of **Typha** reeds in the midst of the marsh close to HBL area may reduce the population of weaverbirds and munias visiting the study areas drastically. This measure could work effectively in case of red munias, as these birds do not depend in ' non-rice vegetation ' for spending the day, other species. Within each study area, either total removal of the tree line or pruning the canopy of the trees in the tree line and avoiding of growing sugarcane would deprive the availability of day roost sites for the bird pests. This would even discourage the roseringed parakeets whose activity is also dependent on the availability of tree cover (Anon., 1984).

If the removal of tree cover or modifying the vegetation is not feasible, it is advisable to try crop substitution (Dyer and Ward, 1977) during the dry season as bird pestilence increases during the dry season resulting in severe damage. Hence, during the dry season it is advisable to rotate other agricultural crops like legumes, with the bird-susceptible rice crop. Such damage evasion measures to save corn crop from the menace of redwinged blackbirds has been successful in Canada (Dyer and Ward, 1977).

Secondly, growing of sugarcane next to rice crop should be avoided as it acts as a convenient day-roost as observed in the present study. The damage to rice crop around the stand of sugarcane will be extremely high (e.g. Chakravarthy and Gubbaiah, 1986).

In addition, removal of all the vegetation in and around the rice field, and not growing sugarcane next to rice fields may result in reduced activity of bayas and munias.

It is also advisable to set apart a small area within the rice fields to grow *Echinochloa colona* or any *Echinochloa* spp. Seed of *Echinochloa* appears to be one of the principle food of finches (Ward, 1965a; Crook and Ward, 1968; Weins and Dyer, 1977). And also, as it was seen during the present study, it was possible to divert the whole population of bird pests during the dry season from rice crop to *Echinochloa* it is possible to use *Echinochloa* as a trap crop when the dry season rice crop comes to maturity. But the cultivation of *Echinochloa* should be so staggered that the maturity of *Echinochloa* coincides with the grainfilling and maturity stages of rice crop, and is available to birds till the mature rice crop is harvested.

5.4 Nesting habits of birds in rice fields.

When the species utilising rice fields for nesting are considered, we find only of birds using two distinct field conditions for nesting in paddy fields. One group includes species that nest in dry fallow fields (larks, pipits and lapwings) and nest during summer before the onset of monsoon. The other group Bluebreasted banded rail (ruddy crane, whitebreasted waterhen, streaked fantail warbler, Indian wren warbler, ashy wren warbler and red munia) that nest only when a crop of standing paddy is available. The fact that birds belonging to the later group start

to nest in rice fields only after the crop has reached late-tillering stage indicates the need for sufficient dense and tall vegetation to offer concealment and suitable emergent substrate for securing their nest. (Immelman, 1971). As a result of such a requirement, various grass dwelling birds are known to begin nest building comparatively late within the specified season (Immelman, 1971). This could be the reason as to why these species nest only in fields with paddy after late tillering.

Of the seven species that place or attach their nest on rice plants, streaked fantail warbler and Indian wren warblers secure their nest on to the standing plants of rice, while the ashy wren warbler and red munias place their nests loosely among the tillers in a clump of standing paddy. The rails on the other hand build platform nests by bending the stems of paddy into a thick wad. Such nesting activities may destroy the crop but such a damage by a few pairs on a few plants is relatively negligible. The habit of these vegetation dependent nesters that place their nests at different levels in addition to preferring paddy stands of different heights (Fig.28) is considered as a method of resource division which permits co-existence (Cody, 1968, 1975). Cody (1968) observed that with addition of tall and dense growth of grasses in grasslands the stratification of feeding niches shifted gradually from horizontal to vertical. Thus, when this pattern is viewed from such an angle, it can be found that streaked fantail warbler and Indian wren warblers which although markedly consume similar foods, vary with respect to materials used for nesting and the vertical nest placement.

Indian wren-warblers secure its nest woven out of paddy plant while, streaked fantail warbler builds its flask shaped nests by fastening the margins of leaf blades and stems with cobwebs. Cobwebs are obtained by birds from spider webs (Ali, 1979) or spider egg sacs (Udea, 1984), that are found abundantly in rice fields (Chatterjee and Dutta, 1979; Udea, 1984), during crop growth.

Red munias, use dry straw and paddy leaves to build their doom shaped nests, while the rails use the living tillers of rice itself. This indicates that each of these species' use of standing rice crop is not merely for food or concealment but also for highly specific nest site requirements.

Munias show a great variation in preference for nest sites and nesting habitats (Ali and Ripley, 1968-74; Whistler, 1949) leading to better reproductive isolation among the members of this group (Lack, 1968).

For the weaverbird, food, nest site and nesting material appear to be important for commencing breeding (Colias and Colias, 1983). The ground nesters seemed to prefer dry fallow fields only for nesting. This is mainly because these species cannot water stagnation (Welty, 1982) or flooding during monsoon (Ali, 1979; Lack, 1968) and tend to breed before the onset of monsoon rains.

Ali (1979), and Ali and Ripley (1968-74) stated that the nesting habits of the streaked fantail warbler and Indian wren-warbler to be

strongly seasonal. But the present study shows that the nesting conditions rather than the season, which influences the breeding of most of the species (Lack, 1933;). The streaked fantail warbler and Indian wren warbler are known to commence nesting with the beginning of monsoon and extend till October. But, during the present investigation these species were active throughout the year except during February to early April when suitable crop was not available. Similarly, Avery (1982), who studied the breeding habits of streaked fantail warblers in the rice fields of Malaysia, found that the nesting activity of the species was synchronous with the availability of standing crop of rice and rice growing regime. As a result, annually two distinct breeding seasons (January to March and June to September) were observed in Bangalore as during intervening period no crop was available. Within each season the warblers had extended breeding season because rice growing was a synchronous (Avery, 1982) among the plots within the study areas. Further, the presence of nesting cover was determined by irrigation schedule.

Lack (1968) and Ali and Ripley (1968-74) observe that the nesting of these species started with the onset of monsoon when they utilize the seasonal flush of vegetation and insect abundance for breeding. This situation, which induces the seasonal nesting cycle among the above species seems to have been disrupted and extended by rice growing which simulates vegetation and insect abundance of monsoon period from late tillering till harvest. These periods as Avery (1982) observed would get further extended due to asynchrony in rice stands among different plots within a rice field.

In Australia, Bell (1982) found that the nesting activity of insectivores was dependent on local periods of optimal plant growth. However, the nesting seasons of weaverbirds and munias appear to conform with those mentioned by Ali and Ripley (1968-74).

The mortality rate of birds especially streaked fantail and Indian wren warblers are extremely high (Table 18,19). When the mortality factors are considered, predation and harvesting emerge as two major causes for egg and nestling mortalities. The modes of predation indicate rodents and snakes as the important predators. Snakes apparently remove the contents of the nests but do not disrupt the nest structure while rodent predators damaged the nests while removing the nest contents (Dahlsten and Copper, 1977 and reference therein). Similar patterns were observed during the study. Lack (1968) observed that the proportion of nests destroyed by predation is much greater in birds that have their nesting in concealed vegetation.

Harvesting was one of the major constraints in the loss of eggs and older nestlings in streaked fantail warblers and egg stage in Indian wren warblers. Beklova. et al (1982) who evaluated the effects of harvesting on three bird species (the mallard, *A. Platyrhynchos*; a partridge, *Perdix perdix*; and a pheasant, *Phasianus colchicus*) recorded a high mortality rate due to the harvest of fodder crop in Czechoslovakia.

Birds are capable of recognizing the proper stage of rice crop at which they commence nesting (Avery, 1982), but are unable to predict

the time of harvest and suitably adjust their nesting cycles resulting in a heavy loss of eggs and young.

SUMMARY

Instead of being active and progressive in nature, with respect to associated species richness, the successional pattern was found to be passive and showed a bimodal trend in species composition.

Even though birds, especially the migrants and breeding residents showed considerable seasonal movements with respect to seasonal weather changes, the continued presence of a majority of birds was disrupted by the rice cultivation cycles during wet and dry seasons. Bird species responded to availability of suitable field conditions. However, there were eight species of strong seasonal migrants, whose activity in rice fields were independent of the field conditions available. Secondly, the nesting cycle of the streaked fantail and indian wren-warbler was synchronous with the growing of rice but was not influenced by seasonal monsoon cycle.

The food habits of bird species varied. The food included soil invertebrates, insects, birds, snakes and rodents.

Soil invertebrates like earthworms, crabs and molecrickets were consumed in large number during preparatory cultivations.

Eight species of birds namely, the pond heron, cattle and little egrets, openbill stork, brahminy kites, brownheaded gull and the white-breasted kingfisher, fed on crabs. Brahminy kites were the major preators, accounting for nearly 70 per cent of the observed crab captures. Majority of the crab captures (upto 72%) by brahminy kites was made during preparatory cultivations and harvesting of rice crop. Crabs were also important in the diets of the pond Heron, whitebreasted kingfisher and

the house crow. Further, crab feeders differed in the methods of crab capturing, use of the substrate for capturing crabs and the age of crabs captured.

Insect feeders included all the warbler, cattle egrets, female weaverbird (during its breeding season), certain aerial foragers like the black drongo, bee-eater, swallow and swifts; Of these streaked fantail warblers fed on the larvae of rice skipper (54.7%), and the rice grass hopper (4.37%). The diets of indian wren-warbler, baya and streaked weaverbirds also included several insect pests of paddy. Brahminy kites, marsh harriers and redheaded merlins, house crows and occasionally fed on vertebrate prey. The bird species recorded also showed a varied type of feeding behaviours. Roseringed parakeet was the only bird pest invading seeded rice nurseries.

These birds with diverse food habits and interrelations constituted an avian food web in rice fields. The food web was replete with all the trophic levels.

The activity pattern of bird pests like the baya weaver birds was influenced by the seasonality in breeding and natural food availability secondly by the suitability of habitat in providing vegetation for seeking shelter and thirdly the threat of being predated by birds of prey. As a result of these three factors, the bayas and munias showed a tendency to select rice fields that had a high shrub and tree cover in and around them and those that were closest to their roosting site.

Within the chosen fields their feeding activity was highly localized with respect to the availability of suitable cover or day roost sites. Such localized pattern of feeding is thought to be a consequence of the efforts to reduce the risk of predation. In addition they preferred to feed on rice varieties that did not curtail or reduce their visibility while feeding. The dwarf varieties with drooping earheads and with erect flag-leaf were not preferred.

Habitat manipulation involving destruction of the main roosts and removal of surrounding vegetation have been considered as proper strategies to reduce the menace of weaverbirds and munias to rice.

The rice field avifauna observed during the study appeared to derive its bird components from two different habitats namely, freshwater marshes and grasslands. The rice field conditions occurring before tillering stage was usually used by ground foragers like egrets, herons and other waders inhabiting open aquatic conditions. The standing crop stages were used by marsh birds that skull^{that} and those_h were predominantly grassland users like the warblers, weaverbirds and munias.

Ten species of birds were observed using rice fields for nesting. Of these five species of birds utilized rice plant stands of different height for placement of their nests. Three species nested in dry cultivated plots during summer.

Streaked fantail warblers and Indian wren warblers were the two common nesters. Partial life tables of these two species indicated predation and harvesting to be two of the key mortality factors.

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APPENDIX

[illegible]

EVIDENCE FOR FAILURE

{ Young capable of leaving nest when last seen [] Young seen leaving naturally [] left when approached []
 { Young seen and heard near nest [] Parent bird(s) : giving alarm, calls [] carrying food []
 { In nest : hatched shells [] feather scale [] droppings []

NEST: empty ☐ damaged ☐ fallen ☐ flooded ☐ removed ☐ EGGS: damaged ☐ deserted ☐
 all infertile or addled ☐ YOUNG: all dead, uninjured ☐ all dead, 1 or more injured ☐
 Any other evidence (e.g. type of weather causing failure, species of predator if seen etc):-

Appendix II Details of vegetation in each of the study areas

Hebbal	Nagavara	Kodigehalli
<i>Cocos nucifera</i> L. <i>Areca catechu</i> L. <i>Eucalyptus</i> hybrid <i>Pongamia glabra</i> Vent. <i>Erythrina indica</i> Lamk. <i>Ficus benghalensis</i> L. <i>Tamarindus indica</i> L. <i>Ficus religiosa</i> L. <i>Pithecellobium dulce</i> (Roxb.) Benth. <i>Azadirachta indica</i> Juss. <i>Psidium guajava</i> L. <i>Syzygium cumini</i> (L.) Skeels <i>Acacia leucophloea</i> (Roxb.) Willd. <i>Salix tetrasperma</i> Roxb. <i>Coffea arabica</i> L. <i>Dendrocalamus strictus</i> (Roxb.) Nees <i>Leucaena leucocephala</i> (Lamk.) DeWit. <i>Synadenium grauntii</i> Hk. <i>Ipomoea muricata</i> (L.) Jacq.	<i>Pongamia glabra</i> Vent. <i>Pithecellobium dulce</i> (Roxb.) Benth.	<i>Cocos nucifera</i> L. <i>Eucalyptus</i> hybrid <i>Pongamia glabra</i> vent. <i>Ficus benghalensis</i> L. <i>Syzygium cumini</i> (L.) Skeels <i>Acacia leucophloes</i> (Roxb.) Willd.

Appendix III a Taxanomic composition and certain ecological characteristics of birds of rice fields

	Residency Status										Utili- zation	Guild		Flocking habit	Micro habitat preference*
	Breeder			Resident			Migrant		Trns	Food		Fora- ging			
	Reg.	Irg.		Reg.	Irg.		Reg.	Irg.							
1	2	3	4	5	6	7	8	9	10	11	12	13			
CICONIFORMES															
Ardeidae															
1. Little Green Heron Butorides striatus (Linnaeus)															
2. Paddybird or Pond Heron Ardeola grayii (Sykes)															
3. Cattle Egret Bubulcus ibis (Linnaeus)															
4. Median Egret Egretta intermedia (Wagler)															
5. Little Egret Egretta garzetta (Linnaeus)															
6. Chestnut Bittern Ixobrychus cinnamomeus (Gmelin)															

(Contd.)

APPENDIX - III a (Continued)

1	2	3	4	5	6	7	8	9	10	11	12	13
7. Ciconidae												
Openbilled Stork				3				F	C	Gd	S	5
Anastomus oscitans (Boddaert)												
FAICONIFORMES												
Accipitridae												
8. Blackwinged kite				1				F	I	H	S	32
Elanus caeruleus (Desfontaines)												
9. Brahminy kite			1,2,3					F	C,I,R	H	S	2-9,12-14,20-24, 31
Haliastur indus (Boddaert)												
10. Shikra				1				F		P-S	S	32
Accipiter badius (Gmelin)												
11. Pale Harrier							1,2	F	N	H	S	32
Circus macrourus (S.G.Gmelin)												
12. Marsh Harrier					1,2,3			F	B,R	H	S	32
Circus aeruginosus (Linnaeus)												
Falconidae												
13. Redheaded Merlin			1,3	2				F	B	H	S,G	31
Falco chicquera Daudin												

(Contd.)

APPENDIX - III a (Continued)

1	2	3	4	5	6	7	8	9	10	11	12	13
22. Yellow-wattled Lapwing Vanellus malabaricus (Boddaert)				2				F	I,S-I	Gd	S	4
23. Golden Plover Pluvialis dominica (Gmelin)							3	FR	I,S-I	Gd	S	1-2
24. Little Ringed Plover Charadrius dubius (Gmelin)					1,2 3			F,R	I,S-I	Gd	G	4,6,9, 12,13
Scolopacinae												
25. Marsh Sandpiper Tringa stagnatilis (Bechestein)						1,2		F	S-I	Gd/ Pb	G	2,5,7,8, 13,23
26. Green Sandpiper Tringa ochropus (Linnaeus)					1,2, 3			FR	S-I	Gd/ Pb	S	2,5-10,13, 14,19,21,23,27
27. Wood or Spotted Sandpiper Tringa glareola (Linnaeus)					1,2, 3			F	I,S-I	Gd/ Pb	S	2,5,7,8,10,13, 14,20,21,23,24
28. Common Sandpiper Tringa hypoleucos (Linnaeus)					1,2, 3			FR	I,S-I	Gd/ Pb	S	2,5,7,8,12, 13,21,23
29. Snipe ** Capella sp.					1,2, 3			F	S-I	Pb	S	10,11,13,14,20 24,26
30. Little Stint Calidris minutus (Leisler)					1,2, 3			F,R	S-I	Pb	G	2,5,7,8,10,12, 13,21,23
31. Temminck's Stint Calidris temminckii (Leisler)						1,2		F,R	S-I	Pb	G	2,5,7,8,10,12, 13, 21, 23

(Contd.)

APPENDIX - III a (Continued)

	1	2	3	4	5	6	7	8	9	10	11	12	13
Rostratulidae													
32. Painted Snipe Rostratula benghalensis (Linnaeus)						1,3			F,CR	S-I	Pb	G	10,11,13,15, 31,23,24
33. Blackwinged Stilt Himantopus himantopus (Linnaeus)						1,2, 3			F,R	S-I	Pb	G	2,5,7,8,11, 13,14,21,23,24
Laridae													
34. Brownheaded Gull Larus brunicephalus (Jerdon)							1,2		F	G	Gd,H	S	3,5,7,8
COLUMBIFORMES													
Columbidae													
35. Blue Rock Pigeon Columbia levia Strickland				1,2, 3					F	G	Gd	G	23,25
36. Spotted Dove Streptopelia chinensis (Gmelin)				1,2 3					F	G	Gd	S-G	17,25
PSITTACIFORMES													
Psittacidae													
37. Rosinged Parakeet Psittacula krameri (Scopoli)				1,2, 3					F	G	Gd/	G	9,17,25

(Contd.)

APPENDIX - III a (Continued)

	1	2	3	4	5	6	7	8	9	10	11	12	13
CUCULIFORMES													
Cuculidae													
38. Plaintive Cuckoo					1,3				F	I	P-S	S	I
Cacomantis merulinus (Scopoli)													
STRIGIFORMES													
Strigidae													
39. Spotted owl		1		2,3					F	I	H,P-S	S	16-20,30
Attene brahma (Temminck)													
40. House Swift				1,2,3					F	I	H	G	30
A pus affinis (Gray)													
41. Palm Swift					1				F	I	H	G	30
Cypsiurus parvus (Lichtenstein)													
CORACIFORMES													
Alcedinidae													
42. Pied Kingfisher				1,2					F	F	PI	S	32
Ceryle rudis (Linnaeus)													
43. Common Kingfisher					1				F	F	PI	S	32
Alcedo atthis (Linnaeus)													

(Contd.)

APPENDIX - III a (Continued)

1	2	3	4	5	6	7	8	9	10	11	12	13
44. Whitebreasted Kingfisher Halcyon smyrnensis (Linnaeus)			1,2, 3					F	C,R	P-S	S	2,3,5,7,8,12, 13,20,21,23, 27,29,30
Meropidae												
45. Small Green Bee-eater Merops orientalis Lathann			1,2					F	I	S	S	29
Coraciidae												
46. Indian Roller Coracias benghalensis (Linnaeus)			1,2					F	I	P	S	I
Upupidae												
47. Hoopoe Upupa epops Reichenbach		2	1					F	I	P	S	I
PASSERIFORMES												
Alaudidae												
48. Ashycrowned Finch Lark Erimopterix grisea (Scopoli)	3				1,2			FN	I	Gd	S	I
49. Skylark Alauda gulgula Franklin	3							FN	I	Gd	S	I
Hirundinidae												
50. Common Swallow Hirundo rustica Linnaeus					1,2			F	I	H	G	7,13,17,22, 23,30
51. Wire-tailed Swallow Hirundo smithii Leach						1,2		F	I	H	G	30

(Contd.)

APPENDIX - III a (Continued)

	1	2	3	4	5	6	7	8	9	10	11	12	13
52. Redrumped Swallow <i>Hirundo daurica</i> Linnaeus					1,2, 3				F	I	H	G	30
Laniidae													
53. Brown Shrike <i>Lanius cristatus</i> Linnaeus						1,2, 3			F	I,S-I	P-S,S	S	29
Dicruridae													
54. Black Drongo <i>Dicrurus adsimilis</i> (Bechstein)					1,2,				F	I	S	S	29
Sturnidae													
55. Rosy Pastor <i>Sturnus roseus</i> (Linnaeus)								I	F	I	Gd	G	1,12,23
56. Common Myna <i>Acridotheres tristis</i> (Linnaeus)				1,2, 3					F	I,S-I	Gd	G	1,3,22,26
57. Jungle Myna <i>Acridotheres fuscus</i> (Wagler)				1,2, 3					F	I,S-I	Gd	G	3,7,22
Corvidae													
58. House Crow <i>Corvus splendens</i> Vieillot					1,2, 3				F	C,S-I	Gd	G	3,22
59. Jungle Crow <i>Corvus macrorhynchos</i> Wagler						1,2, 3			F	C,S-I	Gd	G	3,22

(Contd.)

APPENDIX - III a (Continued)

	1	2	3	4	5	6	7	8	9	10	11	12	13
Musicapidae													
Timalinae													
60. Whiteheaded Babbler					1				F	G,I	Gd	G	25,29
<i>Turdoides affinis</i> (Jerdon)													
Sylviinae													
61. Streaked Fantail Warbler		1,2,							FNCR	I,S	Fg	S	11-19,21
<i>Cisticola juncidis</i> (Rafinesque)		3											24,26
62. Indian Wren-Warbler		1,2,							FNCR	I,S	Fg	S	11-19
<i>Prinia subflava</i> (Gmelin)		3											
63. Ashy Wren Warbler			1		3				FNC	I	Fg	S	19
<i>Prinia socialis</i> (Sykes)													
64. Tailor Bird					1				FC	I	Fg	S	19
<i>Orthotomus sutorius</i> (Pennant)													
65. Great Reed Warbler							1		F,C	I	Fg	S	28
<i>Acrocephalus stentoreus</i>													
(Hemprich and Ehrenberg)													
66. Blyth's Reed Warbler							1		F,C	I	Fg	S	28
<i>Acrocephalus dumetorum</i> Blyth													
67. Paddyfield Warbler						1,2,			F,C,R	I	Fg	S	16-19
<i>Acrocephalus agricola</i> (Jerdon)						3							
Turdinae													
68. Bluethroat						1,2,			FCR	I	Gd	S	23-24,26-29
<i>Eritacus svecicus</i> (Linnaeus)						3							

(Contd.)

APPENDIX - III a (Continued)

	1	2	3	4	5	6	7	8	9	10	11	12	13
69. Pied Bush Chat Saxicola caprata (Linnaeus) Motacillidae				1,2					F	I	S,P-S	S	29
70. paddyfield Pipit Anthus navaeaeelandiae (Gmelin)		3	1	2					FN	I	Gd	S	1
71. Greyheaded Yellow Wagtail Motacilla flava thumbergi (Billberg)						1,2, 3			FG	I	Gd	S	3,4,10,11 23,26
72. Grey Wagtail Motacilla caspica (Gmelin)						1,2, 3			F	I	Gd	G	2,4-9,12, 18,27
73. Large Pied Wagtail Motacilla maderaspatensis (Gmelin) Ploceidae Passarinae			1,2	3					F	I	Gd	G	2,4-9,12;13
74. House Sparrow Passer domesticus (Linnaeus) Ploceinae				2	1				F	G	Eg	G	17
75. Baya Ploceus philippinus (Linnaeus)				2,3					F,N	G,I	Fg Eg	F	15-19
76. Streaked Weaver Bird Ploceus manyar (Horsfield)					3				F	G,I	Fg Eg	G	15-19

(Contd.)

APPENDIX - III a (Continued)

	1	2	3	4	5	6	7	8	9	10	11	12	13
Estrildinae													
77. Red Munia Estrilda amandava (Linnaeus)		1		2	3				FNC	G	Gd	G	1,17
78. Whitethroated Munia Lonchura malabarica (Linnaeus)				1,2					F	G	Eg Gd	G	2,17
79. Whitebacked Munia Lonchura striata (Linnaeus)				1	2				F	G,A	Eg	G	2,17
80. Spotted Munia Lonchura punctulata (Linnaeus)				1,2, 3					F	G,A	Eg Gd	G	2,17
81. Blackheaded Munia Lonchura malacca (Linnaeus)			1	1,2, 3					FN	G,A	Eg Gd	G	2,17

* For description of microhabitats, see Appendix - IIb

Study Areas: 1 = Hebbal; 2 = Nagavara; 3 = Kodigehalli

Residency Status of species: R = Residents; Br = Breeding Resident, M = Migrant from North India or Palaearctic region;

Trans = Transient, Reg = Seen, More or less regularly; Irg = Encountered once or utmost few times in the study area

1 = Hebbal study area; 2 = Nagavara study area; 3 = Kodigehally study area

Utilization: F = Foraging; N = Nesting; C = Cover; R = Roosting

Guild: a) Food: G = Granivore, I = Insectivore, S = Spider-eater, C = Crab-eater, R = Rat-feeder, NF = Not seen feeding in the

study area, S-I = Soil invertebrate feeder

b) Foraging: Gd = Ground glean, Fg = Foliage glean; Ps = Perch-to-site,

Sy = Sally, H = Hawking, Eg = Earhear glean; Pg = Probing wet mud

** As per the observations of Searight (1930) the species identity was not attempted. Also, Aliand Ripley (1968-74) indicate that

C. gallinago is indistinguishable from C. stenura (Bonaparte) in field.

**Appendix - III b Details of different microhabitats utilized by birds
in rice fields**

Micro habitat code	Description of micro-habitats
1	Dry uncultivated, weedy
2	Uncultivated inundated
3	Operations: ploughing, puddling levelling
4	Ploughed plot, wet
5	Ploughed plot, inundated
6	Puddled plot, wet
7	Ploughed plot, inundated, weedy
8	Puddled/levelled plot, inundated
9	Seeded nursery
10	Nursery with young seedlings
11	Nursery with full grown seedlings
12	Transplanted plot, wet
13	Transplanted plot, inundated
14	Transplanted plot, early-tillering stage
15	Transplanted plot, late-tillering stage
16	Plot with standing crop before grain filling stage
17	Plot with standing crop from grain filling to grain maturity
18	Standing crop with wide gaps at places
19	Standing crop with tall statured crop
20	Edges of inundated plot with standing crop
21	Standing crop plots alternating with plowed, puddled, levelled or harvested patches

- 22 Operation : Harvesting
 - 23 Harvested plot with stubbles, inundated
 - 24 Harvested plot with sprouted stubbles, weedy, inundated
 - 25 Harvested plot with grains strewn on the ground
 - 26 Bund between plots with standing crop
 - 27 Nala with shallow water
 - 28 Standing crop field close to shrubs, bushes
 - 29 Fence posts along field edges, stakes at the edge of plots,
 stakes inside harvested plots
 - 30 Aeria, canopy or above canopy of paddy crop
 - 31 Un recorded
 - 32 Fish pond amidst paddy plot
-

Appendix - IV Details of bird species, frequenting different field conditions in paddy fields*
(Total species 81)

Field conditions	Bird Species	No.of species
1. Uncultivated plot, Dry	Cattle Egret, Redwattled Lapwing, Indian Roller, Ashycrowned Finch lark, Skylark, Common Myna, Pied Bush Chat, Indian pipit	8
2. Uncultivated plot, inundated	Pond Heron, Cattle Egret, Little Egret, Brahminy Kite, Redwattled Lapwing, Golden Plover, Little Ringed Plover, Green Sandpiper, Spotted Sandpiper, Common Sandpiper, Little Stint, Temminck's Stint, Blackwinged Stilt, Brownheaded Gull, Whitebreasted Kingfisher, Common Myna, Jungle Myna, House Crow Jungle Crow, Yellow Wagtail, Grey wagtail	16
3. Ploughed plot,inundated	Pond Heron, Cattle Egret, Medium Egret, Little Egret, Openbilled Stork, Brahminy Kite, Redwattled Lapwing, Yellow-wattled Lapwing, Little Ringed Plover, Marsh sandpiper, Common Sandpiper, Little Stint, Temminck's stint, Blackwinged Stilt, Brownheaded Gull, Whitebreasted Kingfisher, Common Myna, Jungle Myna, House Crow, Jungle Crow, Yellow Wagtail, Grey wagtail	24

(Contd.

Appendix - IV (Continued)

Field conditions	Bird species	No.of species
4. Puddled/levelled plot, inundated	Pond Heron, Cattle Egret, Median Egret, Little Egret, Openbilled Stork, Brahminy Kite, Redwattle Lapwing, Yellow-wattled Lapwing, Little Ringed Plover, Marsh Sandpiper, Little Stint, Temminck's Stint, Blackwinged Stilt, Brownheaded Gull, Whitebreasted Kingfisher, Common Myna, Jungle Myna, House crow, Yellow wagtail, Grey Wagtail, Large Pied Wagtail	24
5. Nursery, inundated	Pond Heron, Cattle Egret, Little Egret, Redwattled Lapwing, Little Ringed Plover, Green Sandpiper, Spotted Sandpiper, Common Sandpiper, Little Stint, Temminck's Stint, Painted Snipe, Roseringed Parakeet, Whitebreasted Kingfisher, Yellow wagtail, Grey wagtail, Large Pied Wagtail	16
6. Transplanted plot, inundated	Pond Heron, Cattle Egret, Little Egret, Brahminy Kite, Redwattled Lapwing, Little Ringed Plover, Marsh Sand-	

(Contd.)

Appendix - IV (Contd)

Field conditions	Bird species	No. of species
	piper, Green Sandpiper, Spotted Sandpiper, Common Sandpiper, Common snipe, Little Stint, Temminck's Stint, Painted Snipe, Blackwinged Stilt , Whitebreasted Kingfisher, Grey Wagtail, Large Pied Wagtail.	18
7. Transplanted plot, crop in early tillering stage	Pond Heron, Cattle, Egret, Little Egret, Common Snipe, Painted Snipe, Whitebreasted Kingfisher, Common Swallow, Redrumped Swallow, Wire-tailed Swallow, Brown Shrike, Yellow Wagtail.	11
8. Plot with the crop in late tillering stage	Pond Heron, Cattle Egret, Bluebreasted Banded Rail, Baillon's Crake, Ruddy Crake, Whitebreasted Waterhen, Common Snipe, Spotted Owlet, Painted Snipe, White-breasted Kingfisher, Common Swallow, Wiretailed Swallow, Redrumped Swallow, Brown Shrike, Black Drongo, Common Myna, Streaked Fantail Warbler, Indian Wren Warbler, Paddyfield Warbler, Pied Bush Chat, Bluethroat, Yellow wagtail	22

Appendix - IV (Contd)

Field conditions	Bird species	No. of species
	Warbler, Blyth's Reed Warbler, Pied Bush Chat, Blue-throat, Yellow Wagtail, House Sparrow, Baya Weaverbird, Streaked Weaver Bird, Red Munia, Whitethroated Munia, Whitebacked Munia, Spotted Munia, Blackheaded Munia.	39
11. Harvested Plot inundated	Pond Heron, Cattle Egret, Little Egret, Brahminy Kite, Redwattled Lapwing, Green Sandpiper, Spotted Sandpiper, Common Sandpiper, Common Snipe, Painted Snipe, Blackwinged Stilt, Blue Rock Pigeon, Spotted Dove, Roseringed Parakeet, Whitebreasted Kingfisher, Common Swallow, Redrumped Swallow, Common Myna, Jungle Myna, Bluethroat, Yellow wagtail, Grey Wagtail, Large Pied Wagtail, Whitethroated Munia	24
12. Harvested plot with sprouted stubbles weedy inundated	Pond Heron, Cattle Egret, Little Egret, Brahminy Kite, Pleasant-tailed Jacana, Redwattled Lapwing, Common Snipe, Painted Snipe, Whitebreasted Kingfisher, Common Swallow, Redrumped Swallow, Streaked Fantail Warbler	12

APPENDIX - V Details of frequency of sighting, flock size and mean fortnightly values for birds at different study areas

Sl. No.	Bird species	STUDY AREAS										
		Hebbal					Nagavara					Kodigehalli
		Frequency of sightings	Maximum flock size	Fortnightly mean maximum	Frequency of sightings	Maximum flock size	Fortnightly mean maximum*	Frequency of sightings	Maximum flock size	Fortnightly mean maximum*	Frequency of sightings	
1	2	3	4	5	6	7	8	9	10	11		
1.	Little Green Heron	1	1		1	1		-				
2.	Pond Heron	162	69	51.00 (Mar. '84)	66	34	21.00 (Jan. '84)	70	34	22.25 (May '84)		
3.	Cattle Egret	65	116	57.40 (Jan. '84)	16	59	11.46 (Feb. '84)	13	33	11.00 (Feb. '84)		
4.	Smaller Egret	2	6	3.00 (June '83)	3	4	2.33 (Sep. '83)	-	-	-		
5.	Little Egret	97	33	12.78 (Jan. '83)	33	25	15.50 (Feb. '84)	9	6	11.00 (Feb. '84)		
6.	Chestnut Bittern	1	1	-	1	1	-	-	-	-		
7.	Openbilled Stock	-	-	-	-	-	-	-	-	-		
8.	Blackwinged Kite	2	1	-	-	-	-	-	-	-		
9.	Brahminy Kite	136	29	20.00 (Aug. '83)	57	32	24.00 (Aug. '83)	66	9	6.00 (Sep. '83)		
10.	Shikra	3	1	-	-	-	-	-	-	-		
11.	Pale Harrier	2	1	-	-	-	-	1	1	-		
12.	Marsh Harrier	64	2	1.25 (Nov. '83)	19	1	1.00 (Jan. '84)	29	4	1.50 (Oct. '83)		
13.	Redheaded Merlin	13	2	-	2	2	-	6	2			
14.	Bluebreasted Banded Rail	9	5	4.00 (July '84)	2	1	-	2	5			
15.	Bailion's Crake	1	2	-	-	-	-	-	-	-		
16.	Ruddy Crake	11	8	10.50 (July '84)	1	1	-	-	-	-		
17.	Whitebreasted waterhen	- 71	16	-	-	-	-	1	1	-		
18.	Kora or the Watercock	3	1	-	-	-	-	-	-	-		
19.	Pheasant-tailed Jacana	-	-	-	6	11	3.80 (July '83)	-	-	-		
20.	Greyheaded Lapwing	-	-	-	-	-	-	-	-	-		
21.	Redwattled Lapwing	39	9	4.50 (Aug. '84)	19	7	2.67 (Aug. '83)	32	17	10.50 (Jan. '84)		
22.	Yellowwattled Lapwing	-	-	-	2	2	-	-	-	-		
23.	Golden Plover	-	-	-	-	-	-	1	1	-		

(Contd..)

1	2	3	4	5	6	7	8	9	10	11
24.	Little Ringed Plover	16	34	7.00 (Feb. '83)	13	28	12.50 (Feb. '84)	4	7	3.33 (Jan. '84)
25.	Marsh Sandpiper	7	7	4.00 (Mar. '83)	1	1	-	-	-	-
26.	Green Sandpiper	98	44	16.60 (Feb. '83)	28	11	4.50 (Jan. '84)	13	8	4.75 (Jan., '84)
27.	Wood or Spotted Sandpiper	71	242	157.86 (Mar. '83)	35	200	179.00 (Apr. '84)	23	53	26.00 (Mar. '84)
28.	Common Sandpiper	27	3	2.50 (Apr. '83)	3	2	1.00 (Apr. Jan. '84)	1	1	-
29.	Snipe (Capella sp.)	47	15	8.60 (Feb. '83)	24	6	4.50 (Apr. '83)	22	3	2.50 (April '83)
30.	Little Stint	17	77	24.33 (Mar. '82)	21	61	29.00 (Feb. '84)	2	2	1.50 (Dec. '83)
31.	Temminck Stint	9	16	4.50 (Mar. '83)	4	8	4.00 (Feb. '84)	-	-	-
32.	Painted snipe	13	17	-	-	-	-	2	3	1.00 (Aug. '83)
33.	Blackwinged stilt	36	100	60.50 (Mar. '83)	128	33	17.33 (Aug. '83)	4	24	8.00 (Jan. '84)
34.	Brownheaded Gull	1	1	-	4	3	-	-	-	1.00 (Mar. '84)
35.	Blue Rock Pigeon	40	88	31.00 (Dec. '83)	8	52	17.33 (Dec. '83)	12	152	120.67 (June '83)
36.	Spotted Dove	23	4	3.00 (June '83)	5	2	1.50 (Nov. '83)	1	1	-
37.	Roseringed Parakeet	37	201	74.67 (Aug. '83)	9	153	60.67 (July '83)	14	52	49.50 (June '83)
38.	Plaintive Cuckoo	1	1	-	-	-	-	1	1	-
39.	Spotted Owlet	-	-	-	-	-	-	-	-	-
40.	House Swift	4	11	3.67 (Feb. '84)	3	15	9.00 (Mar. '84)	2	16	6.95 (Apr. '83)
41.	Palm Swift	6	7	5.67 (Apr. '83)	-	-	-	-	-	-
42.	Pied Kingfisher	56	4	3.50 (May '84)	3	3	1.33 (May '83)	-	-	-
43.	Small Blue Kingfisher	18	1	-	1	1	-	-	-	-
44.	Whitebreasted Kingfisher	143	7	6.00 (July '84)	51	6	4.00 (Nov. '83)	45	3	3.00 (Sep. '83)
45.	Small Green Bee-eater	3	2	-	1	1	-	-	-	-
46.	Indian Roller	2	1	-	-	-	-	7	2	-
47.	Hoopoe	2	2	-	-	-	-	-	-	-
48.	Ashycrowned Finch Lark	1	1	-	1	1	-	10	5	4.50 (Apr. '83)
49.	Skylark	-	-	-	-	-	-	4	5	1.67 (Apr. '83)

(Contd..)

1	2	3	4	5	6	7	8	9	10	11
50.	Common Swallow	29	18	17.16 (Mar. '83)	32	125	87.33 (Mar. '84)	23	32	11.67 (Mar. '84)
51.	Wiretailed Swallow	1	2	-	1	1	-	-	-	-
52.	Redrumped Swallow	5	3	3.00 (June '83)	1	2	2.75 (Feb. '84)	3	2	1.25 (Apr. '83)
53.	Brown Shrike	30	2	-	1	1	-	8	1	-
54.	Black Drongo	6	2	-	6	1	-	9	2	-
55.	Rosy Pastor	2	224	37.33 (Mr. '83)	-	-	-	-	-	-
56.	Common Myna	92	20	9.00 (June '84)	8	10	5.00 (June '83)	21	4	3.50 (June '83)
57.	Jungle Myna	126	112	29.25 (Nov. '83)	26	18	14.33 (Aug. '83)	27	12	15.50 (Aug. '83)
58.	House Crow	88	44	43.00 (Sep. '82)	25	31	26.67 (July '83)	31	16	14.00 (Sep. '83)
59.	Jungle Crow	5	6	10.00 (Sept. '83)	1	14	3.50 (Feb. '84)	5	3	4.00 (May '84)
60.	Whiteheaded Babbler	6	5	2.67 (Apr. '83)	-	-	-	-	-	-
61.	Streaked Fantail Warbler	149	159	5.75 (Nov. '83)	65	32	22.00 (Apr. '84)	65	43	33.00 (Nov. '83)
62.	Indian Wren Warbler	119	19	11.00 (May '84)	42	15	33.00 (Nov. '83)	29	7	4.00 (May '83)
63.	Tailor Bird	4	2	-	-	-	-	-	-	-
64.	Great Reed Warbler	2	1	-	-	-	-	-	-	-
65.	Blyth's Reed Warbler	1	1	-	-	-	-	-	-	-
66.	Ashy Wren Warbler	25	4	3.50 (Apr. '83)	-	-	-	-	-	-
67.	Paddyfield Warbler	21	5	2.00 (Feb. '84)	14	39	24.25 (Jan. '84)	11	20	10.67 (Jan. '84)
68.	Bluethroat	39	8	5.60 (Jan. '84)	14	5	8.00 (Feb. '84)	14	14	3.33 (Feb. '84)
69.	Pied Bush Chat	15	2	-	4	3	2.00 (May '83)	-	-	-
70.	Paddyfield Pipit	70	6	4.00 (Feb. '84)	11	4	2.00 (May, June '83)	15	4	13.75 (Apr. '83)
71.	Greyheaded Yellow Wagtail	58	660	206.67 (Apr. '83)	34	372	174.00 (Apr. '83)	23	53	32.75 (Apr. '83)
72.	Grey Wagtail	69	5	4.25 (Nov. '83)	3	2	-	2	1	-

(Contd..)

1	2	3	4	5	6	7	8	9	10	11
73.	Large Pied Wagtail	92	8	5.00 (Mar. '84)	17	2	-	4	2	-
74.	House Sparrow	1	33	-	14	142	53.00 (July '83)	-	-	-
75.	Baya Weaverbird	88	260	208.50 (Apr. '83)	9	14	7.00 (June '83)	4	8	5.00 (Sep. '83)
76.	Streaked Weaverbird	-	-	-	-	-	-	1	7	-
77.	Red Munia	76	260	160.00 (Apr. '83)	6	19	16.50 (May '83)	18	36	19.33 (Jan. '84)
78.	Whitethroated Munia	18	12	12.00 (July '82)	10	28	10.75 (Feb. '84)	-	-	-
79.	Spotted Munia	94	670	335.00 (Apr. '83)	18	77	42.33 (Dec. '83)	3	2	-
80.	Whitebacked Munia	85	218	-	1	1	-	-	-	-
81.	Blackheaded Munia	56	186	54.25 (July '83)	4	4	9.00 (Mar. '84)	1	3	-

* Months and year in parentheses indicate months when the mean fortnightly maximum was recorded.

APPENDIX - VI

Observed food habits of certain bird species in paddy fields of Bangalore

Sl. No. 1	Bird species 2	Common name of the prey 3	Frequ-ency(%) 4	Remarks 5
1.	Fond Heron	Crabs	88.89	Oziotelphusa sp.
		Mole crickets	2.78	Gryllotalpa sp.
		Water scorpion	2.78	Laccotrephes sp. (Nepidae)
		Others	5.56	Soil invertebrates identity unknown N = 36
2.	Cattle Egret	Crabs	76.74	Oziotelphusa sp.
		Mole crickets	23.26	Gryllotalpa sp. N = 43
3.	Little Egret	Crabs	(3)	
4.	Openbilled Stork	Crab	(1)	
5.	Brahminy Kite	Crabs	93.96	Paratelphusa sp.
		Dragon flies	5.52	Lebillulidae
		Snake	0.17	Tropidonotus psicator
		Rat	0.17	Bandicoota bengalensis
		Ruddy crane	0.17	Amourornis fuscus N = 580
6.	Marsh Harrier	Snake	(1)	
		Rat	(1)	Bandicoota bengalensis
		Little Egret	(1)	Egretta garzeta
		Green Sandpiper	(1)	Tringa ochropus

(Contd.)

Appendix - VI (Continued)

1	2	3	4	5
7.	Redheaded Merlin	Baya	(2)	Ploceus philippinus
		Indian wren warbler	(1)	Prinia subflava
		Indian pipit	(1)	Anthus navaeseelandae
8.	Brownheaded Gull	Crabs	(3)	Oziotelphusa sp.
9.	Spotted Sandpiper	Dipteran larvae	(2)	Unidentified
10.	Common Sandpiper	Caterpillar	(1)	Noctuidae
11.	White-breasted Kingfisher	Crabs	97.46	Oziotelpausa sp.
		Streaked fantail warbler	1.28	Cisticola juncidis
		Mice	1.28	Mus musculus
				N = 76
12.	Small Green Bee-eater	Dragon on-flies	(4)	Lebillulidae
13.	Black Drongo	Dragonflies	(5)	Lebillulidae
		Plant bug	(1)	Nazara virudula Linnaeus
14.	Brown Shrike	Frog	(1)	2.5 cm in length, Brown colour with pale motlings usually found in irrigation nals in paddy fields
15.	Common Myna	Paddy horned caterpillar	(1)	Melanitis leda-ismanae (Cromer)
		Mice	(1)	Mus musculus
		Unidentified caterpillar	(1)	feeding on Jussia repensl.
16.	Jungle Myna	Spiders	(12)	Unidentified
		Mole Crickets	(4)	Gryllotalpa sp.

(Contd.)

Appendix - VI (Continued)

1	2	3	4	5
17.	House Crow	Spiders	0.81	
		Earthworms	18.71	Curgina narayana
		Mole crickets	11.38	Gryllotalpa sp.
		Grasshopper	1.63	Oxya fuscovittata
		Cricket		Logrillus sp.
		Moth	0.81	Pyrilidae
		Plant bug	0.81	Nazara virudula Linnaeus
		Crabs	62.60	paratelpusa sp.
		Munia	0.81	Londhura sp.
		Common myna	0.81	Acridotheres tristis N = 103
18.	Jungle Crow	Crabs	(1)	Paraptelpusa sp.
19.	Streaked Fantail Warbler	Grass hopper	4.37	Oxya fuscovittata
		Damselfly	0.40	Zygoptera
		Cricket	0.79	Gryllidae
		Paddy skipper larvae	54.76	Pelopedis mathias Fabricius
		Moth		adults Noctaidae
		Paddy horned caterpillar	0.40	M.L. ismanae
		Moth	1.98	adults of Pysalidae
		Leaf folder caterpillar	0.77	Cnaphalocrosis medianalis Guenee
		Larvae	0.79	Spodoptera sp.
		Crane fly	0.79	Tipulidae
		Fly	0.79	Diptera
		Spiders	4.37	Araneae
		Grasshoppers	6.75	Unidentified Acrididae
		Others	23.02	Unidentified N = 257
20.	Indian Wren Warbler	Paddy skipper larvae	48.15	P.mathias
		Grass hopper	18.52	Acrididae
		Horned caterpillar	3.70	

(Contd.)

Annexure - VI (Continued)

1	2	3	4	5
		Spiders	14.82	
		Others	14.82	Unidentified
21.	Pied Bush Chat	Grasshoppers	(1)	N = 25 Oxya fuscovittata
22.	Indian Pipit	Grasshopper	(4)	Acrididae
		Moth	(1)	Pyralidae
		Wasp	(1)	Hymenopterans
		Others	(1)	Unidentified
23.	Yellow wagtail	Caterpillar	(1)	Unidentified
		Grasshopper	(1)	nymph of Oxya fuscovittata
24.	Baya Weaverbird	Grass hopper	21.43	Oxya fuscovittata
		Long horned grasshoppers	4.76	
		Other grasshopper	2.38	Unidentified Acrididae
		Dragonfly	4.76	Labillulidae
		Damselfly	11.91	Zygoptera
		Paddy skipper larvae	54.76	P.mathias N = 40
25.	Streaked weaver bird	paddy skipper larvae	(5)	P.mathias

Values in parentheses are actual numbers.

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ಗಾ.ಕೃ.ವಿ.ಕೆ, ಬೆಂಗಳೂರು-65.

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