I. INTRODUCTION

Birds constitute an important component of agro-ecosystems which provide a concentrated and highly predictable source of food to them in the form of grains, seeds, fruits, green vegetation of the crop plants and grasses, insects, other arthropods, rodents etc., that are found in the soil, crop and other plants (O'Connor and Shrub 1986). In India especially in the cultivated areas of Tamil Nadu and Punjab, there are a variety of birds including insectivores, granivores, frugivores, carnivores, nectarivores and omnivores (Dhindsa and Saini 1994). Recently the significance of insectivorous birds has been receiving greater attention especially as biocontrols for agricultural pests (Daniels 1991).

Nagai Quaid-E-Milleth District, Tamil Nadu, South India in which the present study was undertaken is regarded as the "Granary of South India" understandably due to its vast agricultural areas where insect pest management is problematic leading to adoption of various strategies to overcome the same. Of late, the use of biological controls have been a major component in Integrated Pest Management (IPM) strategies. As such, our understanding of the ecological role of insectivorous birds in this agro-ecosystem becomes an essential component. Further, an understanding of the ways in which birds exploit the resources available to them, in their search for food and shelter, is important for predicting the consequences of man made changes in the environment as well (Brooker et al., 1990).
Role of birds as natural controls of insect pests have been well documented in the agro- (Parasharya et al., 1994) as well as forest-ecosystems (Bruns 1960, and Franz 1961). Franz (1961) cited 229 references to illustrate that birds along with insectivorous bats, small mammals, microbes and predatory insects help to hold insect pest populations at endemic levels or exert some control during early stages of an outbreak. DeGraaf and Evans (1979) stated that if insect outbreak occurs when insectivorous bird populations are at sufficient densities, the birds tend to concentrate in those areas of outbreaks and buffer, contain or possibly eliminate losses. Concentrations of insectivorous birds at insect infestation sites had been reported by Blackford (1955), Yeager (1955), Morris et al. (1958) and Koplin (1969) also. DeGraaf and Evans (1979) were of the opinion that additional benefits could be derived if natural predators are used to control pests as biological control agents. This may eliminate or reduce the expanse of pesticide resistance problem and environmental danger of pesticide application will help to buffer insect epidemics.

The small Green Bee-eater *Merops orientalis* has been regarded to play a significant role in the control of agricultural insect pests in the crop lands of South India (Mathew et al., 1978, Daniels 1991). In spite of its undoubted significance in agro-ecosystems, reports on its ecology are few and sporadic (Ali 1979, Ali and Ripley 1983, Joshua and Johnsingh 1988 Sridhar and Karanth 1993), although extensive reports on its counterparts viz., European Bee-eaters are available (Fry 1984, Lessells and Krebs
1989). So the present study was undertaken to understand their population fluctuations, food and feeding strategies and breeding in order to fill up the lacuna in our knowledge and undoubtedly it will go a long way in planning agro-pest management strategies.

An important aspect of the ecology of insectivorous birds pertains to factors that influence their numbers and richness. A general concept that birds select habitats based on vegetation structure or habitat physiognomy has been expressed by several researchers (Lack 1933, Svardson 1949, Odum 1950, Hilden 1965, James 1971). Avian population densities can also be influenced by the singular or interactive influence of predation, intra and interspecific resources competition, parasites and diseases, habitat availability and weather (den Boer and Gradwell 1970, Andrewartha and Birch 1984, Begon and Mortimer 1986, Thiyagesan 1991). The magnitude of the influence of these factors may vary in importance according to geographical area, food habits and migratory status of the birds (Lack 1966, von Haartman 1971, Newton 1980, van Balen 1980). Researches on the relationships between the above mentioned factors and population fluctuations of the small Green Bee-eater *M. orientalis* in Indian peninsula are wanting. Herein, a seasonwise and habitatwise population fluctuations were therefore assessed in the present study, in conjunction with other factors that influence them. Such an investigation, would help in understanding their ecological significance in an agro-environment.
Another important aspect of insectivorous birds is their foraging ecology and our present knowledge of food of Indian birds is largely based on the findings of Ali (1979) and Ali and Ripley (1983), Mason and Maxwell-Lefroy (1912) cited by Narang et al. (1978). Ali (1979) Ali and Ripley (1983) gave a general account on the food and feeding habits of *M. orientalis*. Mason and Maxwell-Lefroy (1912) analyzed the food of 100 species of birds collected at Puna, Bihar. Their findings added valuable information on the food of birds in the central provinces. Hussain and Bhalla (1937) studied the food of 93 species of birds at Lyallpur. Beresford (1944) and Simwat and Sidhu (1973, 1974) also added to our knowledge in the subject. All these authors have made a qualitative assessment of food of birds. Mukherjee (1976) was perhaps the first in India to make a quantitative assessment of the food of birds. Realizing that information on food availability is important in understanding the life history (characteristics) of birds, Hutto (1990) made a perusal of a dozen ecological and ornithological Journals published since 1978, located 155 articles on land birds that dealt specifically with the relationship between food supply and several ecological patterns such as timing of annual cycles, territoriality, habitat selection and territory placement, diet, mating systems, clutch size, reproductive success, population size, geographical distribution and community structure. Significance of perch characteristics (hunting perch) in birds have been highlighted by several authors (Franzblau and Collins 1980, Bell 1982, Bell and Ford 1986, Hutto 1990). Role of foraging substrates in prey selection in insectivorous birds had been brought out by Douthwaite and Fry (1982), Bell and Ford (1990), Hutto (1990). Feeding techniques and proportion of use of different techniques
under different conditions of prey availability and competition are another aspect of insectivorous birds’ foraging niche separation (Bell 1985a, Brooker et al. 1990). The food and feeding habits of small Green Bee-eater *M. orientalis* and their relationships with food availability, habitat structure, reproductive state of the bird etc. have not yet been fully elucidated by previous studies and so, an evaluation of their foraging ecology formed an essential component of the present investigation.

Activity budget analysis has been useful in determining ecological, behavioural and physiological adaptations of avian species. Analysis of time budget allows evaluation of temporal relationships of behaviour relative to habitat component and structure (Wiens et al., 1970 quoted in Plumpton and Lutz 1993). Changes in time activity budgets through time are often used to determine seasonal differences in behaviour (Quinlan and Baldassarre 1984, Bergan et al., 1989, Beyer and Haufler 1994) or changes due to progressive phases of the nesting cycle (Verner 1965, Dwyer 1975, Afton 1979, Maxson and Bernstein 1984 or to describe dominant relationships (Paulus 1983, Hepp and Hair1984), foraging strategies (Alexander 1979). The proportion of time spent foraging and time budget studies can also indicate the relative abundance of food (Bell and Ford 1990). Based on these considerations, the time activity budget of the small Green Bee-eater, *M. orientalis* was also analyzed presently.

A guild may be defined as a group species that exploit the same class of environmental resources in a similar way without regard to taxonomic position (Root 1967). An advantage of studying guilds include
directing attention towards all species regardless of taxonomic similarity, defining which set of conditions are necessary for a species or group of species to exist in a habitat type. The small Green Bee-eater belongs to the flycatching guild and the other prominent members of this guild at the study area are the black Drongo, *Dicrurus adsimilis* and the Blue jay, *Coracias benghalensis*. As such, any meaningful assessment of Bee-eater foraging ecology should include a comparison with its co-guild members and so the foraging behaviour of the above mentioned two members of the flycatching guild in the study area were also studied and compared with that of the small Green Bee-eater so as to understand the basis of niche separation.

Avery (1989) analysed the hatching asynchrony pattern of nestling growth and mortality, and evaluated the brood reduction hypothesis and its relationship to hatching asynchrony in the European Bee-eater *M. apiaster* in southern France. A study on age and breeding of Bee-eater *M. apiaster* was made by Lessells and Krebs (1989). Lessells (1990) studied on helping at the nest in European Bee-eater and gave an overview of helping behaviour, the types of individuals who become helpers and the selection pressures that favour helping rhythm. Jones et al. (1991) used DNA finger printing technology in conjunction with detailed field observations over eight years (1983-1990) to analyse the helping behaviour of European Bee-eater *M. apiaster*, which, in turn helped in identifying the parentage of chicks. Studies of Wrege and Emlen (1991) brought out the significance of social factors primarily intraspecific factors and nest parasitism on the breeding performance of the white fronted Bee-eater *Merops bullockoides*. Role of helpers in the breeding of Bee-eater, *M. apiaster* was investigated by Crick (1992). Emlen and Wrege (1992) studied the parent-offspring conflict and the recruitment of helpers among Bee-eaters. Dispersal of close relatives within a breeding colony of European Bee-eater, *M. apiaster* was investigated by comparing the separation of breeding relatives with those between the same individual and a control individual, hatched nearby in the same year in southern France (Lessells et al., 1994). From the foregoing account it is clear that even though a large number of works have been carried out on European Bee-eaters, the breeding ecology of the small Green Bee-eater *M. orientalis* remains poorly known, the same was therefore undertaken presently to fill the gap.
The objectives of the present study are:

1. To study habitatwise and seasonwise fluctuations of Bee-eater *M. orientalis* populations and the probable factors that influence the same,
2. To investigate the food and feeding habits of *M. orientalis* and the factors associated with them,
3. To analyze the time activity budget of *M. orientalis*,
4. To understand the basis of niche separation among the three flycatching insectivores at the study area viz., the Bee-eater, the black Drongo and the Blue jay and
5. To understand the basis of breeding ecology of *M. orientalis*.

The present study was conducted at 150 km$^2$ area around Mannampandal (11°18' N latitude, 79°50' E longitude, Mayiladuthurai) in the Cauvery Delta of Nagai Quaid-E-Milleth District, Tamil Nadu, South India and the study period is from January 1991 to December 1993.