1. INTRODUCTION

It has been said that birds could exist without man but that man would perish without birds. This observation has been further amplified by the remark that ‘But for the trees the insects would perish, but for the insects the birds would perish, but for the birds the trees would perish and to follow the inexorable law of Nature to the conclusion of their awful vengeance, but for the trees the world would perish’. An impartial scrutiny of the facts, shows that there is indeed little extravagance in either of these speculations (Ali 2002).

A large proportion of the normal food of birds consists of insects, including many that are in the highest degree injurious to man and his concerns. Birds of many species not only take heavy toll of the marauding locust hordes all along their flight lines, but also scratch up and devour their eggs in vast quantities as well as the different stages of the young locust after hatching. The White Stork is a well known locust destroyer, and the enormous nesting colonies of the Rosy Starling live and feed their young exclusively upon these insects on their common breeding grounds in central Asia. An idea of the extent of good birds do in destroying insect pests may be had from that many young birds in the first few days of their lives consume more than their own weight of food in 24 hours. A pair of starlings has been observed to bring food (caterpillars, grasshoppers, locusts, etc) to their nest-young 370 times in a day and according
to Collinge, cited in Ali (2002) the well known British authority, House Sparrows bring food (caterpillars, soft bodied insects, etc) from 220 to 260 times per day. A German ornithologist has estimated that a single pair of tits with their progeny destroys annually at least 120 million insect eggs or 1,50,000 caterpillars and pupae. This warfare is waged not only when the insects are at the peak of their periodical abundance, but incessantly, relentlessly and in all stages of the insects’ lives. Therefore where birds have not been unwisely interfered with, they constitute one of the most effective natural checks upon insect numbers (Ali 2002).

Birds are good friends of farmers as they exercise biological control over injurious crop pests. Many birds play very significant beneficial roles in agro ecosystems. Biological method is safe when compared to pesticide. Birds play an important economic role as a cheap and easily raised source of protein food. The faecal matter of birds, called guano is extensively used as fertilizer as it contains nitrogen, phosphorus, calcium and so on. Feathers are used for ornamental purposes. The stomach oil of the short tailed shearwater is used as beverage medicine rich in vitamin, a lubricant and as a fuel for lamps.

As many as 13% of the world’s birds have been recorded in the Indian subcontinent. This includes 141 endemic species, a total comprising of 10% of the region’s avifauna.
Although it is well known that insectivorous and predatory birds play a very useful role in controlling insect and rodent pests of crops, only a few attempts have been made to evaluate their role and that to only in case of insectivorous birds.

Patel et al., (1987) found that House Sparrow, Common Myna, Red-vented Bulbul and three other bird species in addition to wasps play important role in reducing Catopsilla species larvae in medicinal crop *Cassia angustifolia*. Several species of insectivorous birds have been found to feed on insect pests of crops including *Helicoverpa armigera* (Chakravarthy 1988, Parasharya *et al.*, 1988, Singh *et al.*, 1990). In doing so some of these species transmit nuclear polyhedrosis virus infecting *H. armigera* to healthy larvae of this pest (Vyas *et al.*, 1988a). Birds as predators of some other insect pests have also been reported to play an important role in biological control of insect pests through disease transmission (Battu 1987, Vyas *et al.*, 1988b) besides direct predation.

Recently the significance of insectivorous birds has been receiving greater attention especially as bio control agents against agricultural crop pests (Daniel 1991, Asokan 1996). Significance of perch characteristics (hunting perch) in birds had been highlighted by several authors (Franzblau and Collins, 1980, Bell 1982, Bell and Ford 1986, Hutto 1990 and Asokan 1996).
Despite ecological importance and global awareness of conservation nothing has been done to protect rare and threatened species in intensively cultivated areas. Gaston (1984) examining the status and distribution of endemic passerine species in India and Pakistan, suggested that such species may become vulnerable to extinction in areas where habitat destruction is extensive. The populations of birds of prey have been reported to have dwindled to insignificant levels because of habitat destruction and food chain poisoning (Dhindsa 1984). Agricultural areas in India probably experience the most heavy and indiscriminate use of pesticides leading to direct and indirect mortality of predatory and frugivorous birds (Dhindsa 1986). The population of Sarus crane _Grus antigone_ has been reported to have declined in some parts of India due to agricultural expansions (Parasharya _et al._, 1988). There has hardly been any information on residue analysis and other toxicological aspects on birds of agricultural habitats.

Recently, fast moving vehicles have been reported to constitute a new factor of bird mortality on roads in agricultural habitats. Dhindsa _et al._, (1988) found that roads in Punjab were rich food sources for birds and predicted that birds’ mortality on roads would occur as a result of the advent fast vehicles and improvement in road conditions. Bird mortality on roads has also been recorded in Rajasthan (Sharma 1988).
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.

In spite of White-breasted Kingfisher’s undoubted significance in agro-ecosystems, reports on its ecology are few and sporadic (Ali 1979) Ali & Ripley 1983, Joshua and Johnsingh 1988, Sridhar and Karanth 1993), although a few reports on its counterparts viz. Lesser Pied Kingfishers are available (Reyer, 1980). So the present study was undertaken to understand its 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 White-breasted Kingfisher *Halcyon smyrnensis* in Indian peninsula are very few (Elangovan 1988). 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 its ecological significance in an agro-environment.
The present study was carried out in an area of 150 Sq.km. in and around Nagapattinam. This area is endowed with agricultural lands, garden, river, pond etc., providing unique niches for Avifauna. Further, this area is almost lacking in avifaunal works. A perusal of literature on insectivorous birds indicates that the studies on the White-breasted Kingfishers are very few (Elangovan 1988 and Gandhinesan 2000) and preliminary and so the population study of Kingfishers formed one of the objectives in the present investigation.

The Kingfishers, belonging to the order Coraciiformes, are characterized by long, straight compressed bill, linear nostrils, moderating long tail and wing, small and weak feet, frequently crested plumage and acute nails. The hallux is shorter than inner toe and is partly connected with it.

Though the members of the family Dacelonidae are commonly called Kingfishers, many are not primarily fish feeders and hence, they are able to survive away from water. On the feeding techniques of these birds, it is a wonder to know how these three species of Kingfishers are able to share a similar habitat. Competition between birds having similar food requirements such as Kingfishers is inevitable because their food items, feeding and mode of feeding are largely similar in the habitat where they live. If two birds or two different species compete for the same food, one harvests it more efficiently than the
other, that species will lower the resource level to a point where it can survive but its competitor cannot (Diamond, 1978).

Many species of Kingfishers were found in a similar habitat and one would expect a sharing of niche among the coexisting species of birds. An ecological form of resource partitioning occurs when different species coexist in the same habitat and have the same general food requirements, either feed on similar or on different items or on different sizes of food. Such a feature is reported as resource partitioning (Welty 1982). Whitefield and Blabber (1978) have described the diet of three piscivorous birds in a similar habitat, which is based on regular availability and abundance of different prey species.

The bill shape is generally suggestive of feeding habits, being laterally flattened and dagger like in species that regularly dive into water after slippery aquatic prey, but dorso-ventrally flattened and more scoop like in species that catch small animals on the ground and especially wide in those forest species. The birds’ ability to turn the head through a wide angle allows fixation of the object with the binocular vision of the temporal fovea. The cone cells of Kingfishers are also especially rich in the droplets of red oil that signal excellent color vision (Grimmett et al., 2006).
A guild may be defined as a group of 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 White-breasted Kingfisher belongs to the “wait,/ hovering and hunting” guild and the other prominent members of this guild at the study area are the Lesser paid Kingfisher *Ceryle rudis*, and the Small Blue Kingfisher *Alcedo atthis*. As such, any meaningful assessment of White-breasted Kingfisher foraging ecology should include a comparison with its co-guild members and so the foraging behaviour of the above mentioned two members of the “wait,/ hovering and hunting” guild in the study area were also studied and compared with that of the White-breasted Kingfisher so as to understand the basis of resource partitioning among them.

Our present knowledge of food of Indian birds is largely based on the findings of Ali (1979), Ali and Ripley (1983), Mason and Maxwell-Lefroy (1912) cited by Narang et al., (1978). Ali (1979) and Ali and Ripley (1983) gave a general account on the food and feeding habits of the Kingfisher. Mason and Maxwell-Lefroy (1912) analysed 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. Mukkerjee (1976) was perhaps the first in India to make a quantitative assessment of the food of birds. Realizing that information of 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 (Fronzblau and Collins 1980, Bell., 1982, Bell & Ford 1986 and Hutto 1990). Role of foraging substrates in prey selection in birds had been brought out by Douthwaite and Fry (1982); Bell and Ford (1990) and Hutto (1990). Feeding techniques and proportion of use of different techniques under different conditions of prey availability and competition are another aspect of insectivorous bird’s, foraging niche separation (Bell 1985a, and Brooker et al., 1990).
The food and feeding habits of the White-breasted Kingfisher and their relationship with food availability, habitat structure, reproductive state of the bird etc. have not been fully elucidated by previous studies and so, an evaluation of their foraging ecology formed an essential component of the present investigation.

Vegetation structure is reported to be related to habitat use. Further, vegetation structure is deemed to be more important than food as a factor influencing habitat use, even though the importance of vegetation lay with its effects on food availability.

Diurnal activity analysis has been useful in determining ecological, behavioural and physiological adaptations of avian species. Analysis of time budget allows evaluation of temporal relationship of behaviour relative to habitat component and structure (Wiens et al., 1970 quoted in Plumpton and Lutz 1993). Changes in time activity budget 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 Hair 1984) and 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 White-breasted Kingfisher, *Halcyon smyrnensis* was also analysed presently.

Birds show varying degrees of adaptation to the foods they eat. Welty (1982) has stated that the food and feeding behaviour of birds are influenced by many factors such as method and speed of locomotion, acuteness of sense organs, physiological bent of bird, diurnal or nocturnal activity, character of beak and tongue, shape and strength of feet, type of plumage, physiological tolerance for high and low temperature and wet and dry habitats, digestive competence, tolerance thresholds for certain food ingredients, such as toxins, acids, salts and roughage, parental training, experience and habitats.

Lessells and Avery (1989) analysed the hatching asynchrony pattern of nestling growth and mortality, and evaluated the brood reduction hypothesis and its relation to hatching a asynchrony in the European Bee-eater *Merops apiaster* in southern France. 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 Bee-eaters. The reproductive success of *A. atthis* was made by Libois (1994). Foods brought to the nest by breeding *A. atthis* in the New forest of Southern England was reported by Reynolds & Hinge (1996). From the foregoing account it is clear that even though a large number of works have been carried out on Bee-eaters, the breeding ecology of the White-breasted Kingfisher (*Halcyon smyrnensis*) remains poorly known, the same was therefore undertaken presently to fill up the gap.

In view of the foregoing account the present work on the Ecology of the White-breasted Kingfisher *Halcyon smyrnensis* was undertaken with the following objectives:

1. To estimate the habitat-wise and season-wise variations in the population density of White-breasted Kingfisher in agricultural lands and river banks in and around Nagapattinam

2. To estimate the prey preference index of the White-breasted Kingfisher
3. To investigate the food and feeding habits of White-breasted Kingfisher through its regurgitated pellets.

4. To compare the foraging behaviour of White-breasted Kingfisher with the Lesser Pied Kingfisher *Ceryle rudis* and the Small Blue Kingfisher *Alcedo atthis*

5. To analyse and compare the time activity budget of White-breasted Kingfisher with the Lesser Pied Kingfisher and

6. To understand the breeding biology of the White-breasted Kingfisher in the study area.