Chapter 5:

DISCUSSION
Plant Phenology

Phenology indicates quality of forest system and serves as an important attribute for evolving management programme for any forest (Balsubramanian & Bole, 1993; Chhangani, 2004).

Newton (1988) based on his studies on dry deciduous forest in the highlands of central India, concluded that peak flowering coincides with hot weather or summer, despite some flowers and fruits being available throughout the year. The present study revealed that in primary lateritic semi evergreen forest also, peak flowering and leaf shed is during summer. But some or other canopy and undergrowth flora is in bloom or fruition throughout the year.

The observations during the current study as to the phenological parameters of teak plantation, flowering extending the most of the monsoon, fruiting during post monsoon and leaf fall in winter are in conformity with the earlier studies in other parts of the country (Singh et. al. 2001).

Cashew in its native is known to bear flowers in March and April, and the fruits maturing approximately 3 months after, turning to bright yellow or red (www.desert-tropicals.com). In the course of present study, in Goa flowering in cashew was noticed to commence fairly early by December reaching a peak in March and bore fruits till the end of summer i.e. May.

Acacia is said to have flowers throughout the year, with timing of peak bloom varying with locality (Booth & Turnbull, 1994). During the present study it was found that acacia in the region has a definite flowering season from September to February.

Undergrowth

The undergrowth in any natural forest is a normal component of the ecosystem contributing immensely for its healthy floral and faunal diversity. There are differences in opinions regarding the normalcy of undergrowth in plantations. Some workers are of the view that plantations prevent understorey vegetation, thus resulting in decreased biodiversity and increased soil erosion, ultimately resulting in loss of fertility (Poore and Fires, 1985; Abbasi and Vinithan, 1997; Reversat, 2001). On the contrary others
(Gledenhnys, 1997; Harrington and Ewel, 1997) found that plantations helped in establishment of undergrowth plants from surrounding forests, thus regenerating the biodiversity, increasing fertility and animal population (Brosset, 1997; Mboukou-Kimbatsa et al. 1998).

In the present study also it was observed that undergrowth in NF was more diverse than that at all the monoculture plantations, though not significantly different. The finding is in consonance with those of earlier workers (Poore and Fires, 1985; Abbasi and Vinithan, 1997; Bouvet, 1998). It is relevant to note that even in secondary natural forest, the undergrowth has been observed to be more diverse than in plantations (Reversat, 2001).

On the other hand, in terms of density the undergrowth in TP as well as AP was as good as in NF. It could be due to fairly advanced age of these plantations over 20 years, and also their close proximity to the primary forest. An improvement in the undergrowth with the increase in age of plantation is said to be a common phenomenon (Parrotta, 1999; Abbasi and Vinithan, 1999). Further, the positive influence of proximity of natural forest on undergrowth has already been suggested (Parrotta, 1993).

The undergrowth in CP was completely different from other sites owing to its significantly lower diversity and higher density. This appears to be principally because of the dominance of the weed, Chromolena odorata in the undergrowth and its extensive vigor. The weed is known to be allelopathic not allowing any other vegetation to establish in its surroundings (Muniappan, 1994).

Undergrowth densities as well as diversities in all the study sites showed seasonal variations, with abundance in monsoons and post monsoons. It also correlated positively with rainfall. It is only but natural, as annual herbs dominated the undergrowth in all the study sites. Secondly the rainfall appears to be one of the important limiting factors regulating the undergrowth in NF as well as plantations in subtropical belt.

Plant indicators are known to be of great value in finding out the potentiality and capability of lands. They have been used extensively as an aid in determining the suitability of lands for various land use purposes (Devaraj, 1999). The plant, Clerodendron viscosum is identified to be an indicator highlighting favorable soil condition while others such as Holarrhena
antidysentrica and Helicteres isora are supposed to indicate unfavorable soil states (Lal, 1992). On the basis of these criteria, the occurrence of the former species in the undergrowth at NF, CP and AP; and occurrence of the latter species in undergrowth at TP amount to indicate that soil in TP is poorer than that in other study sites.

Litter

A substantial portion of the accumulated nutrients in the plant biomass is returned to the soil through litterfall (Vidyasagaran, 2002). Therefore, the litter with the associated events such as litterfall, litter decomposition and nutrient release is an important component of biogeochemical cycles. Nitrogen fixing plants are known to have higher litterfall (Parrotta, 1999). The findings in the course of present study that the litterfall in AP was significantly higher compared to NF and other plantations is substantiating the observation, as Acacia has nitrogen fixing potential, being a leguminous plant. The regulation of litterfall has been attributed to various environmental factors such as water stress, light intensity, photoperiod, mineral deficiency and mechanical effect of rain (Bray and Gorham, 1964). Quite a few studies have shown that peak litterfall during summer is a common feature in many forest types and plantations (Baker, 1983; Pande and Sharma, 1986; Sanchez & Alvarez Sanchez, 1995) and water stress has been identified to be an important regulating factor. In the present study the seasons with maximum litterfall were noted to be different for NF and the plantations. The leaf fall was more in summer in NF, while it was at its peak in TP and CP in winter and in AP during postmonsoon. Therefore it appears that besides environmental factors, genetically preprogrammed physiognomy of plant species might also be regulating the phenomenon, and hence the variations in the peak seasons of litterfall in monoculture plantations. However the response of heterogenous flora of NF might collectively be falling in line with majority of the forest systems with peak litterfall in summer in tune with water stress.

A negative correlation between litterfall and rainfall has been reported in forests of subtropical belt (Sharma & Ambasht 1987; Pant & Tiwari, 1992), which was also true with NF in the present study. According to Misra &
Nisanka (1997), no relation exists between temperature and litterfall, which is substantiated by the current observations in different plantations.

Singh et. al. (1993) in the course of their studies on litter decomposition in plantations of teak, sal, poplar and eucalyptus in the Central Himalayan subtropical belt observed higher decomposition rate in teak, which they attributed to a series of factors such as physical and chemical properties of leaf, fast disappearance of nitrogen and calcium content, and perhaps to the presence of high termite population at the site. Similar findings on teak litter during the present study indicate that the decomposition of the litter of teak is faster in tropical region also.

Singh et. al. (1993) also opined that litter of the species having highest nitrogen content showed the fastest rate of decomposition and that with lowest nitrogen content decomposed very slowly. The slowest decomposition of acacia litter having highest nitrogen content observed in the present study is diagonally contrary to the said view. Hence, something other than nitrogen content might also be determining the rate of decomposition of leaf litter of different plant species. Leathery texture and high levels of polyphenols might be responsible for the retarded rate of decomposition in acacia litter as reported earlier in semi-humid tropics of Togo (Drechsel et. al. 1991). Joshi et. al. (1999) observed a positive correlation between the loss of weight in decomposing litter of five different tree species and atmospheric temperature in subtropical tarai of Uttar Pradesh. Contrarily a negative correlation was found between the parameters in the current study at all the sites, but for TP. The variations in subtropical and tropical conditions could be responsible for the differences.

Austin (2002) noted that low rainfall lead to lower production of litter and also its decomposition in tropical Hawaii. Many other workers in the field (Pant and Tiwari, 1992; Singh et. al. 1993; Joshi et. al. 1999), who observed higher rate of litter decomposition in monsoon credited it to suitable atmospheric temperature and moisture for microbial activities and also to leaching of water soluble substances from the bio-mass. Thus the findings of the present study that litter decomposition rates in NF as well as other plantations were higher in monsoon than those of other seasons are in concurrence with the earlier studies cited above.
Maheshwaran and Gunatilake (1988) observed an increase in concentrations of N and P content in the decomposing litter of some common forest trees in Sri Lanka with the increase in duration. Misra and Nisanka (1997) arrived at similar conclusions based on their studies on the litter of *Casuarina* in subtropical region. The identical results obtained in the present work as to the behaviour of N and P in the decomposing litter of the NF and other plantations but for TP, confirm it to be a general phenomenon, but for few isolated exceptions. Microbial immobilization, translocation, inputs through precipitation, addition through insect frass, leaching from fresh litter are listed to be the series of factors responsible for the phenomenon in isolation or combination (Bocock, 1964; Gosz et. al. 1973; de Catanzaro & Kimmins, 1985). The teak litter also can't be considered as clear exception to the general trend; taking in to account the marginal rises in P content in it through intervening phases. The totally different annual picture could be owing to the fastest rate of decomposition of teak litter because of its paper-thin texture.

Immobilization of potassium is also reported by some workers in different parts of globe (Lousier & Parkinson, 1978; de Catanzaro & Kimmins, 1985 and Upadhyay & Singh, 1989). But the precipitous or gradual release of the element from the decomposing litter in all the sites in the present study is in agreement with the findings by some of the earlier works (Maheshwaran and Gunatilake, 1988; Misra & Nisanka, 1997).

**Soil nutrients**

The soil system depends largely on organic materials for the nitrogen content because it is not constituent of rocks (Singh and Mudgal, 2002). The high C: N ratio in the tree leaf litter has the potentiality to enrich the soil by liberating the nutrients for the growing vegetation. Nutrients added through litterfall maintain fertility of the soil. Higher accumulation of litter on soil surface under the plantations are known to enhance soil carbon (Jha et. al. 2000) and nitrogen (Singh et. al. 2001). Likewise the likelihood of higher nutrient store in soils with higher organic matter is an established fact because it provides more exchangeable site available to hold nutrient against
leaching losses besides acting as a nutrient reservoir (Santos, 1997). In view of the above sighted facts the highest levels of carbon, nitrogen and potassium in the soil in AP paralleling with significantly higher litterfall at the site is but natural. It may also be noted that Santos (1997) recorded higher potassium content in the soil at Eucalyptus plantations coinciding with higher organic matter.

In this background, the lowest levels of all the nutrients in the soil of TP compared to those at NF as well as other plantations observed in the present work are self explanatory. The lowest litter production and least accumulation of the same owing to its fast decomposition must be the contributory factors for the observed results. The lower nitrogen levels in the soil of TP noticed in the present work are in agreement with similar findings by Singh et al. (2001) in subtropical belt of Arunachal Pradesh. But it is difficult to comprehend the higher carbon contents obtained by the same authors in the soil in TP compared to that in NF in contrast with our findings. The authors have neither provided the profile of litter fall in NF in the region nor the extent of undergrowth in teak plantation studied by them. Therefore one plausible explanation is that, more dense multistoryed flora in NF in the high rainfall (3500 –5000mm/Yr) belt of Arunachal Pradesh might be exerting greater demand on the nutrients of soil which in turn might be responsible for lower levels of carbon in natural forest compared to teak plantation.

Organic carbon and nitrogen are considered to be the main factors responsible for soil fertility and hence to ascertain the soil condition (Jha et al. 2000). The root systems of Acacia are also known to contain nitrogen-fixing bacteria, which can help in rejuvenation of the poor soils (Khanna, 1994). The higher levels of nitrogen and carbon in acacia plantation recorded in the present study besides the occurrence of the indicator plant species Clerodendron viscosum confirm beyond doubt the soil fertility improvement potential of the plantation species.

In deciduous species, the immediate demand of the resumption of entire foliage mass every year, necessitate the recovery of nutrients by translocation from the dying foliage, because acquisition of nutrients through active absorption from the soil is costlier (Pande and Sharma, 1993). In this regard the teak is considered to be much more efficient in nutrient
conservation, returning less amount of nutrients through leaf fall to the floor (Pande and Sharma, 1993). In view of the above facts, the poor quality of litter and soil in TP observed in the present study is self explanatory.

Insects

There are differences of opinions as to the relation between richness of plant species and insect abundance. According to Risch et. al. (1983) the loss of plant diversity causes lower insect richness and higher abundance. Conversely Haddad (2001) through his field experiments carried out at Minnesota opined that higher plant species richness increased insect species richness as well as abundance. In the present study higher insect abundance was noticed in all plantations compared to the natural forest, but no perceptible change in diversity was noticeable, thereby partially confirming the view of Risch et. al. (1983)

In Malaysian tropical Dipterocarpus forest the ants (Formicidae) constituted the largest portion of insect fauna, the beetles being second largest and orthopterans with smallest representation (Wong, 1986). Present study confirms the observation and goes a step further ascribing the dominant status to the Formacid ants of Hymenoptera, not only in natural forests but also in the plantations with the exception of Acacia, wherein they acquired 2nd place. Though the orthopterans were a small group in Malaysian forest, in the present study they were found to occupy first place in AP and 2nd or 3rd place in other sites, prescribing the supremacy of the order amongst insects in this part of the world. The orthopterans were predominantly represented by Gryllus sp. in NF as well as all the plantations probably owing to its omnivorous food habits (Veeresh and Rajagopal, 1983; Ganihar, 1990) coleopterans gained 2nd or 3rd rank in the present study sites. Thus proving beyond doubt that the 3 orders Hymenoptera, Orthoptera and Coleoptera dominated the insect world in natural forests as well as many plantations in tropical belts.

Long-term studies in tropical forests have demonstrated that insect populations exhibit pronounced seasonal fluctuations (Levings & Windsor, 1982; Wolda & Wong, 1988; Develey and Peres, 2000). Further, they
are reported to be abundant in tropical forests during rainy season (Fogden, 1972; Charles-Dominique, 1971). In the present study, in all the study sites the insect abundance was observed to be consistently higher in monsoons. It also showed positive correlation with rainfall in acacia and cashew plantations. High food availability in the form of newly germinating herbs and sprouting shoots for herbivores; decomposing organic matter to detritivores; and these herbivores and detritivores serving as prey to predators might have collectively contributed to the phenomenon. Besides, the flowering in teak and acacia in mid and late monsoon respectively might also have added to nectarivores in the season. The higher diversity and abundance of insects in TP compared to all other study sites observed in the present study is in agreement of the view that broad leaved deciduous forests support more insects (Haartman, 1971).

**Birds**

**Buffering of the plantation effect**

Bird communities have been frequently used for assessing the conservation programmes, monitoring the wildlife habitats (Daniels, 1989; Raman & Sukumar, 2002) and also planning their management aspects (Williamson, 1970).

The diversity of bird species is said to increase with increasing diversity of vegetation (Ripley, 1978). The food resources such as fruits and flowers are said to influence distribution patterns of many forest birds. Some of the capture based studies from Central and Southern America showed that bird population showed positive correlation with the availability of food resources spatially as well as temporally (Levey 1988; Loiselle and Blake, 1991 and 1993). Further structurally complex vegetation types are known to provide greater stability to resource availability (Janzen, 1967) thereby increasing the diversity of the fauna exploiting the resource (Smythe, 1974). In this background, the marginally better abundance of birds, and their reasonably higher diversity observed in natural forest in the current study is but natural in view of the flowering and fruiting, spread across the year owing to its diverse tree population and the undergrowth.
In the present study the plantations, particularly those of teak and cashew were observed to be closely on the heels of the NF in terms of bird abundance and diversity despite the marginal edge of NF over plantations. It may be because of one or more of the following factors. All the plantations studied had natural forests in close proximity on one or more sides.

Secondly certain amount of floristic heterogeneity existed within the plantations because of a few indigenous / native forest trees. Thirdly plantation floors had undisturbed substantially diverse or dense undergrowth.

These findings may have to be viewed in the backdrop of some of the earlier reports. Bell (1979) observed lower bird diversity in teak plantation compared to that in rainforest of New Guinea, and went a step ahead to suggest the preservation of rainforest areas adjacent to the plantations to improve the situation. Studies on pine plantations in Central Chile (Estades and Temple, 1999) showed that vegetation adjacent to plantations or forest fragments had significant positive impact on the birds inhabiting them. An enhanced avian use of pine stands in Puerto Rico was reported because of heterogeneity provided by understorey shrubs, vines and few retained upper storey trees (Cruz, 1988).

Khan (1978) based on his studies in Nilgiri Hills reported that Acacia supported least number of bird species 'as food is almost absent' in the plantation. However, in the course of present work though acacia was found to harbour substantially lower bird diversity, in terms of abundance it was only marginally lower than natural forest and the other plantations. It may be noted that even though Acacia doesn't produce plenty of nectar or edible fruits, their plentiful seeds are considered to be valuable food resource for the birds, particularly in dry places (Khanna, 1999). Even in the present study the Red vented- and Red whiskered- Bulbuls were seen to feed on the seeds of Acacia. Secondly Acacia plantation supported abundant insect fauna more than that of natural forest and the cashew plantation, naturally catering the needs of insectivorous birds. Therefore it is obvious that AP supported fairly abundant bird fauna, though least compared to those at other sites studied.
Undergrowth & the birds

In drier countries due to absence of undergrowth few birds are reported to occur in plantations (Smith, 1974). On the other hand plantation areas with high rainfall such as Congo were shown to permit development of undergrowth thereby favouring the occurrence of birds (Loumelo and Huttel, 1997). Reversat (2001) opined that abundance of undergrowth determined the diversity and density of birds in plantations. On the contrary, Duncan and Chapman (1999) were of the view that the abundance of birds in old plots might contribute to the dispersal of the seeds of undergrowth vegetation, resulting in the maintenance and the increase in its diversity and density. In the present study undergrowth in TP and AP was on par with that in natural forest in density; while though lower was not significantly different in diversity. The condition might be owing to the high precipitation in the region besides the higher age of over 20 years of stabilized plantations. It may be noted that the undergrowth in all the study sites correlated positively with rainfall. In CP significantly poor undergrowth diversity might be due to its significantly high density, made possible by overpowering weed Chromolena odorata. Thus fairly better undergrowth in all the plantations might also have contributed to the abundance and diversity of birds in them being identical or near identical with those of natural forests.

Impact of environment and physiognomy

The negative correlation registered between bird abundance and rainfall in lateritic semievergreen forest currently studied, is in concurrence with similar observation by Jayson and Mathew (2000 a & b and 2002) in evergreen forest of southern Western Ghats. But such a correlation was not seen in plantations of moist deciduous teak or evergreen species like cashew and acacia. On the contrary, AP had highest bird diversity in monsoon/postmonsoon and lowest in summer. In view of the peak flowering in the plantation in monsoon and also concomitant rise in insect abundance at the site and the total absence of flowers or fruits in summer seem to be the obvious reasons for the observed phenomenon. The bird abundance in TP was in summer and it also showed positive correlation with sunshine and
negative correlation with humidity. It seems to be the reflection of greater patronage of insectivores for the plantation, and leafless state of deciduous teak trees in winter/early summer facilitating better view and free sallying of insectivorous birds. It is noteworthy that Robin and Davidar (2002) were also of the opinion that leafless branches of deciduous trees might be offering unobstructed view for searching the prey. In CP bird abundance correlated with sunshine positively, being highest in winter or summer coinciding with flowering and fruiting seasons respectively. Thus the sum total of physiognomy of plants and associated events rather than environmental factors per se have a greater influence on bird population in natural forest or plantations.

Forest generalists Vs Forest specialists

The alterations in the habitats are known to affect bird population considerably. Different species may respond differently. While most species decrease in their densities, a few may decrease substantially or disappear from the site altogether. In contrast a few species also could increase in abundance in altered habitats. In this whole gamut of changes the common species are known to benefit from habitat disturbances at the cost of rare specialized restricted range species (Leck, 1979; Raman, 2001; Raman & Sukumar, 2002). Carlson (1986) through his studies on pine plantations in Kenya showed that more forest generalist species than forest specialist species were encountered in plantations.

In the present study Red whiskered Bulbul, an omnivore was sighted rarely in natural forest and there were no encounters with the signs of its breeding activity at the site during this 2 year long study. But it was not only frequently observed in plantations occupying 1st & 2nd rank of in dominance in cashew and acacia plantations respectively but also found breeding in all the plantations. Likewise another omnivore, Jungle crow ranking 5th in both cashew and acacia plantations and 10th in teak plantation was absent from natural forest. Oriental magpie Robin was the another generalist bird that was absent from natural forest occurred in all the plantations. It may be noted that Red whiskered bulbul was detected only in spice plantations of cardamom
and not in primary rain forest of Nilgiri sholas (Raman and Sukumar, 2002). Similarly, Reiko and Robert (2003) found that jungle crows were more abundant in small/disturbed forest than in large forests in Japan.

On the other hand the Chestnut-bellied Nuthatch, a foliage gleaner, ranking third in terms of dominance in natural forest was exclusive to this site. The foliage gleaners like nuthatch are known to forage well in moderate to dense foliage, as open areas with few leaves offer reduced insect densities while large size leaves hinder their mobility (Pearson, 1975). Similarly the diet guild based analysis in the present study also showed that the natural forest harbored more carnivores and nonpasserines than all the plantations. Thus the present study concurs and authenticates the concept that only the natural forest with extensive array of microhabitats, diverse and sustained food resource can support forest specialists generally occupying higher trophic levels, while the forest generalists such as omnivores can find refuge in plantations.

**Differential treatment of feeding guilds**

The foraging environment ultimately determines which bird species can successfully exploit and survive in a particular habitat, and as a consequence influences community structure and species diversity of birds (Robinson & Holmes, 1984). Therefore, habitat structure is expected to strongly influence avian guild structure (Vale et. al. 1982). Thus the number of individuals in a guild reflect the availability of the resource supporting it, whereas the number of species included suggest how finally these resources are shared (Wong, 1986). Naturally the similarity in guild structure suggests that similar resource types are available in similar proportions (Wong, 1986; Mac Nally, 1994). Likewise, the dissimilar guild structure suggests that the resource utilization pattern of birds in the varied vegetation types is different (Johnsingh & Joshua, 1994). Besides, difference in food availability the foliage structure of vegetation also influences habitat use by birds (Cruz, 1988).

In the present study the insectivorous birds constituted the dominant guild in natural forest as well as all the monoculture plantations. The findings are in agreement with similar results obtained by earlier workers (Boletta et.
al., 1995 and Giannini, 1999) in Argentinean subtropical forests. Amongst the plantations the insectivores were more in TP on both counts, i.e. abundance as well as diversity. As discussed earlier, the highest abundance of insects in TP compared to other plantations and exposed perches provided by tall teak trees with open canopy, more so in winter/summer owing to their deciduous nature might have been the collective causes for the same. The findings are in consonance with the earlier comparative studies on deciduous and coniferous forest wherein it was shown that former habitat had higher species richness than the latter (Salt, 1957; Winternitz, 1976; Beedy, 1981; Hansson, 2000). It may also be pertinent to note here that ants and beetles were the most frequently found insect groups in bird stomachs in tropical Dipterocarp forests of Malaysia (Wong, 1986). Incidentally these were also the dominant groups of insects in all the study sites in the present study.

While phytophage representation in the plantations neither differed from that at natural forest nor amongst themselves. On the other hand omnivores not only were more in all the plantations compared to those in natural forest, but also were significantly higher in their abundance as well as diversity in the Cashew plantation. The findings are clear reflections of the fact that all the plantations under study met the needs of phytophages on par with the natural forest, while omnivores could show better adaptability to plantations in general and cashew plantation in particular. In this context the observation by May (1982) that the omnivores are expected to do better in disturbed habitats is noteworthy.

Carnivores, though with a smaller representation at all the sites in comparison with other guilds, was better in diversity as well as abundance in natural forest compared to monoculture plantations. This could be because, large bodied carnivores with higher trophic level status might need complex vegetation of a natural forest to meet their niche requirements including the food resources. Thus it is amply clear that like natural forest, different plantations under study catered the needs of feeding guilds differentially.
Residents vs Migrants

As far as wetlands are concerned, wintering waterfowl, especially some of the anatids are known to arrive in huge flocks of large numbers across southern hemisphere including the Goan region (Lopez and Mundkur, 1997; Walia and Shanbhag, 1999; Shanbhag et. al. 2001; and Borges, 2002). They also outnumbered the resident bird population pushing the species evenness ($J'$) to the other extreme in winter/early summer (Walia, 2000 and Borges, 2002). Unlike the phenomenon, even though as large as 22 migrant species including 7 long distance migrants were sighted in study area during the 2 year long study, the resident bird population always dominated over the migrants in abundance as well as diversity at all the sites. The findings are in agreement with similar reports by earlier workers in the secondary forests of Hong-Kong (KwoK, 1996; and KwoK & Corlett, 1999). The occurrence of migratory species in plantations was not much different from that in natural forest, indicating their efforts to exploit the new environment to the fullest extent without much discrimination. However, the maximum migratory species were recorded in teak plantation and seven of them that were exclusive to the site were insectivores. This once again authenticated the better insect resource at the site, besides the insectivore friendly habitat provided by the deciduous plantation. A local migrant, Greenish Leaf Warbler occurred in all the sites with the higher dominance ranks. The species has been reported to winter in high densities in Anaimalai Hill section of Western Ghats also (Kannan, 1998). Like the waterfowl, most of the migratory birds sighted arrived between late monsoon to early winter and stayed up to mid-summer.

**Edge effects**

Ecotone is characterized by rapidly changing species composition. Ecotone has high species diversity, for the reason that they have species from the 2 merging communities. They may also have some additional animal species, which require resources from both kinds of habitats. The increased diversity in ecotones is commonly referred as edge effect. Increasing edge effect is a powerful tool in wildlife management (Lal, 1992). However according to Kruger and Lawes (1997) there was no significant quantitative
differences in bird species diversity between the forest edge and interior. In
the present study bird population on edge was significantly higher than that in
centre in CP & AP. While in TP the situation was reverse, but the difference
was not statistically significant. Though, Hansson (2000) also had found that
the number of species was higher in deciduous woodland centres than at
edges, the reasons for diagonally opposite picture of normal edge effect by
deciduous forests or plantations are not very clear.

Breeding birds

Of the 6 species of birds sighted to breed in NF, 5 such as Lesser
Spotted Eagle, Lesser Golden-backed Woodpecker, Yellow-browed Bulbul,
White-rumped Munia exclusively bred at the site. The only Orange-headed
Thrush that bred at NF also bred in TP. This amount to the fact that some
species needing specific requirements provided by NF for their breeding
probably can’t get easily adopted to altered environments.

The number of species that were found to breed in the 3 plantations
was not much different from that in NF, being 5 each. Interestingly, while
Small Sunbird and Jungle Crow bred exclusively in TP, 2 other species, Ashy
Drongo and Bronzed Drongo were sighted to breed only in AP. Four out of 5
species that bred in CP, i.e. Red Spur fowl, Oriental Magpie-Robin, Jungle
Babbler and Red-vented Bulbul were encountered in breeding state only in
the plantation. Further Red-whiskered Bulbul was found to breed in all the
plantations but not in natural forest. These observations amount to indicate
that selective advantages provided by these plantations such as intensive
insect resource in teak, highly dense undergrowth in cashew and tall nesting
platforms in acacia besides lack of indulgence by carnivorous/raptorial birds
might have lured these birds to breed in them. At this juncture it may be noted
that Khan (1978) stated that “So far as food, shelter, and breeding places are
concerned eucalyptus and acacia plantations provide poor environment as is
evidenced by paucity of breeding birds” in the course of his studies at Nilgiri
hills. In the very publication he recorded the breeding of flycatchers in acacia
plantation and also good number of other breeding species such as Jungle
Crow, Black-and orange-Flycatcher, Nilgiri Verditer Flycatcher, Tickell’s Blue
Flycatcher, White-spotted Fantail Flycatcher, Pied Flycatcher-Shrike, Black Bulbul, Nilgiri Pipit and white eye etc. in eucalyptus plantation.

**New bird sightings for the region**

As far as avifauna of Goa is concerned, initially 154 species were recorded for the region (Grubh and Ali, 1976). Since then the list gradually increased to 208 species (Saha and Dasgupta, 1992). However, thus far most of these studies were short duration opportunistic surveys. A quantum jump was made in this direction by the extremely long duration but once again an opportunistic survey by Lainer (1999 a & b) taking the total to 382 species. Borges and Shanbhag (In press) based on their 2 year long planned survey of esuarine wetlands of Mandovi River added 8 more species and also authenticated an unconfirmed one.

During the course of 2 year long present study across the natural forest and monoculture plantations 13 new sightings have been made. Of these, the occurrence of Indian Blue Robin and Streaked Spider-hunter may have to be confirmed because one individual each was sighted in single encounters. Remaining 11 species are confirmed occurrences as 3-25 individuals of these species were sighted in 3-6 sightings, many of them being repeat sightings across the 2 years of study. Seven of the species were sighted in TP while 5 each were sighted in CP and AP as against 6 in NF, once again kindling a thought as to whether plantations under certain circumstances could be as good habitats as natural forests, if not better.

**Endemism**

Endemism describes species that are native to a particular geographic area or continent. It usually occurs in areas that are isolated in some way. Therefore, as much as it can occur between the continents it can occur within them too. India, because of its position in tropical subtropical latitudes enjoys a status of megabiodiversity country and has 969 species of birds of which 69 are endemic (Gadgil, 1996). The Western Ghats, one of the 25 biodiversity hotspots is known to have 12 endemic birds (Kannan, 1998). In the course of present study, 4 species of birds endemic to Western Ghats were sighted in
the study area, of which the Small Sunbird was found in all the three plantations besides natural forest. All the 4 species were encountered in CP, and Malabar Grey Hornbill was sighted in all the study sites except TP. These facts probably hold a pointer to the fact that monoculture plantations studied, especially CP probably did meet the requirements of some of the endemic birds of the Western Ghats.