The study of pollination of plants and finding out their important insect pollinators of an area has been a challenge because of the diverse insect visitors, their small size, the difficulties in collection of visitation data and their effectiveness, the complexity of plant-pollinator relationship, the relationship of population size according to habitat area and host plant diversity, and the various factors influencing or affecting the pollinators activities and abundance.

Finding out the insect visitor diversity, community composition and assemblage of the study area is the prime requisite for studying the pollinator status of the area and improvement if necessary for the successful propagation and good health of the forest environment of that area. Therefore, insect visitor diversity in Rani Reserve Forest, Assam, India has been studied after selecting the study sites experiencing a great deal of human disturbance ranging from small wood collection to encroachment of forest area for agricultural purposes and human settlements which poses different range of threats to the study area as listed out by Barua (2007). According to Saunders et al. (1991), the destruction and fragmentation of habitats has become one of the major threats to biodiversity which according to Kearns et al. (1998) may change or disrupt mutualistic and antagonistic interactions such as pollination, parasitism and predation. Therefore, the present study focused on the effects of habitat fragmentation on the diversity of insect pollinators and plant-pollinator interactions and threats to them, their host plants and habitats and the conservation recommendations. Similar works has been carried out by Steffan-Dewenter and Tscharntke (2002) on calcareous grasslands and by Hoffman (2005) in terms of land use and agricultural intensity.

5.1.1: Diversity of flower visiting insects and flowering plants in Rani Reserve Forest

It was observed that the highest species and individual numbers were recorded from the order Lepidoptera and Hymenoptera (Fig. 4.1.1. and 4.1.2.). Freitas and Sazima (2006) also recorded hymenoptera with the highest species number in
Tropical high-altitude grassland in Brazil. The results are also supported by the findings of Momose et al. (1998) in Sarawak, Malaysia, Devy and Davidhar (2003) in Kakachi, Western Ghats, India and Corlett (2004) in Oriental (Indomalayan) region. The high number of butterfly species in the study area (Fig. 4.1.1 and 4.1.2) was also recorded by Saikia et al. (2009). The average number of flower visiting beetles in the present finding (Table 4.1.4) unlike Momose et al. (1998) (op. cit.) and Devy and Davidhar (2003) (op. cit.) where they found beetles representing majority of the flower visiting insects may be due to a number of factors in which different host plants composition, different geographic, climatic, and the environmental condition of the study area are concerned.

Insect visitor species diversity was recorded lowest in HD habitat followed by MD and highest in UD habitat (Table 4.1.5) proved the hypothesis that flower visiting insects' diversity changes with habitat fragmentation and thereby it can be inferred that insect visitor species diversity increases with habitat area and decreases with habitat isolation. Similar findings were observed by Steffan-Dewenter and Tscharntke (2002) (op. cit.) but in case of species richness and abundance. However, as against the findings of Steffan-Dewenter and Tscharntke (2002) (op. cit.), MD habitat (with intermediate disturbance) was the highest regarding species richness and abundance (Table 4.1.5), in comparison to UD habitat which proved the Successional Theory predicted by Brown and Southwood (1987) that highest species richness peaks in mid-successional stages of "intermediate disturbance". The finding proved the hypothesis in case of abundance in HD habitat only when compared to UD and MD habitats and it can be inferred that increase of habitat fragmentation and isolation alone cannot decide the abundance and richness of pollinator insects however, their habitat requirements are also necessary. The probable reason for MD habitat with highest species abundance and richness may be due to the fact that the landscape is a mixture of shady portion as well as open space portion with a variety of plants ranging from herbs, shrubs, trees, climbers, bamboos, and ferns. This is supported by the findings of van Dulmen (2001) where he reported that structurally complex vegetation types showed more diverse spectra of pollinators than less complex vegetation.

The overall comparison between the different habitats, however, showed that there were no significant differences between them and the insect orders were also not significantly different in the three habitats except Coleoptera pollinators which were
significantly lower than the other three orders (Table 4.1.6.). This may be due to the fact that the importance of Coleoptera as pollinators is very low except in some specific plants.

The insect visitor species richness and their distributions (Table 4.1.7., 4.1.8. and Appendix no. 1.) were observed to be different at different habitats of the study area with different habitat features, environments and different levels of anthropogenic disturbances. Had the three habitats been similar in vegetation composition, abundance and richness and the anthropogenic disturbances weren't there, there would have been lesser random distributions of insect visitors and more regular distributions and even aggregate distributions in the study area, but since it was not so in this case, there were greater number of random distributions of insect visitor species at different habitats in the study area (Table 4.1.7., 4.1.8.). Similar finding was reported by Subramanian and Sivaramakrishnan (2005) in Western Ghats on insect distributions in different habitat and microhabitat of stream insect communities.

5.1.2: Finding out the pollination systems present in the study area using insect visitor frequencies

In the present study five FGs: bees, butterflies, beetles, flies and other (dragonfly, ants, thrips etc.) were used for finding out the pollination systems of 60 selected plant species (Plate no. 4.). More specifically, Hoffman (2005) (op. cit.) used twelve FGs: flies (non-syrphid diptera), syrphids, Rhingia, beetles, butterflies, moths, ants, wasps, solitary bees, bumblebees, honeybees and other for analysis of pollination syndromes and classification of pollination systems. Brunet (2009) on the other hand, used only two FGs which were nectar and pollen collectors to study the correlation between them and floral traits of Aquilegia coerulea in Rocky Mountain columbine.

Visitor abundance was recorded highest in Terminalia arjuna, Dillenia indica, Tecom stans, Saraca indica, Shorea robusta and Dillenia pentagyna (Table 4.2.3.). And again T. arjuna was recorded highest in linkage levels followed by D. indica, S. indica, T. stans and Eupatorium odoratum (Table 4.2.3.). These host plant species attracts and supports a diverse and abundant number of insect visitors with their floral resources and flower abundance. The cluster-analysis from the study produced
distinct clusters or classes of plant species (Fig. 4.2.1.). The clusters differed in visitor frequencies, and the flower types were largely separated (Table 4.2.2., 4.2.3.). Lepidoptera and hymenoptera were the main characteristic groups for the two main branches A and B respectively (Fig. 4.2.1. and 4.2.2.). Lepidoptera contributed to the majority of visitor frequency in clusters 1 and 2; Hymenoptera (clusters 9, 10, and 11); Diptera group eventhough not the highest contributor to visitor frequency, however, on average they were good contributors in clusters 7 and 8; Coleoptera were not even close to be good contributors, but they were constant visitors in clusters 3 and 11; Other groups were found to be constant in cluster 4 although clusters 3, 10, and 11 had minimal Other visitor groups (Fig. 4.2.2.). Cluster 3, and 4 had the highest mixture of visitor groups (Fig. 4.2.2.).

Two species of Acanthaceae family were concentrated in Branch A (Table 4.2.1. and 4.2.2.). Most of the flowers in Branch A had tube-shaped flower type, half of them were red in colour, all had ample nectar source although pollen were limited except one plant and they had faint to sweet and fragrant flowers which supported the prediction that these flowers were Psychophillous (Table 4.2.2.). This was confirmed by the very findings that the major visitor frequency of this Branch was from Lepidoptera and was also proved in the cluster analysis that these flowers were grouped in Psychophillous pollination system (Table 4.2.2., Fig. 4.2.1. and 4.2.2.). Cluster 6 in Branch B (Fig. 4.2.1.) was surprisingly visited by Lepidoptera group in majority eventhough 4/7 plants had been predicted with both Psychophily in combination with Myophily or Mellitophily (Table 4.2.2.). The reason may be due to the fact that they had Psychophillous flower-shape like tube (3 nos.), gullet (1 no.), and the remaining three had brush, bowl and head which is commonly visited by most of the insect groups (Table 4.2.2. and Fig. 4.2.3.). Therefore, Cluster 6 eventhough it had Hymenoptera and Diptera contributors also, it can be grouped in Psychophily system as because it has Lepidoptera group in majority and they were important visitors for these plants (Table 4.2.3. and Fig. 4.2.2.). While a cluster of 4 plant species was completely Psychophily system, another cluster of 6 species which had Lepidoptera in majority (> 60%) was also categorized under Psychophily system (Fig. 4.2.2). Similar findings were reported by Hoffman (2005) (op. cit.). Except one plant in cluster 5, all the red colour flowers were clustered in Branch A which also supports the floral traits syndrome for Psychophily system. Schemske and Bradshaw (1999) in their study about the pollinator preference of floral traits in monkeyflowers (Mimulus)
reported that bee visitation rate was negatively associated with petal anthocyanin and carotenoid concentration (giving red colouration in flower petals) and positively associated with projected area. Malerba and Nattero (2012) also mentioned of the colour preferences (colour constancy) by different pollinators. This supports the present findings that red colour flower is largely associated with butterfly pollination than bee pollination.

No pure Mellitophily system was recorded but clusters 7, 9, 10 and 11 in Branch B, which had Hymenoptera visitors in majority (> 50%) was categorized under Mellitophily system (Fig. 4.2.1. and Fig. 4.2.2.). As per prediction, 4/10 (majority) of the plants in these clusters had mellitophilous pollination system which was confirmed by the present finding that Hymenoptera group was the major visitor of these clusters (Table 4.2.2. and Fig. 4.2.1., 4.2.2.). Therefore, these clusters were proved to be Mellitophily pollination system. The floral features and pollination syndrome and its respective pollination system recorded in the study were in agreement with the pollination syndrome trait chart prepared by Wyatt (1983) and Buchmann and Nabhan (1996).

As Psychophily and Mellitophily pollination systems were found to be functioning in the 60 host plant species being studied in the study area (Fig. 4.2.2.), it can be inferred that pollination syndromes can be used for the classification of pollination systems in the study area.

In the present study there was no record of specialist plant species from the total plant species recorded for the study (Appendix no. 2.). Generalist plant species may be resilient to pollinator species loss, because pollinator species that have disappeared may be replaced with alternative pollinator species (Waser et al., 1996) unlike specialist plant species that depend on few or single pollinator species which are said to be the most vulnerable, as the loss of pollinator species may leave few or no alternatives (Kearns and Inouye, 1997). However, the two functional groups which were found to be functioning in the study area and giving distinct pollination systems for their particular host plants will become a deciding factor for the faith of these plants. The increase, decline or loss of these plants may be affected by the increase, decline or loss of their responsive FGs and vice versa for their FGs also. It was observed that Hymenoptera and Lepidoptera visitor group are important FGs for the pollination of the plant community selected for the study. Hence, for the conservation of these plants, conservation of these groups should be a priority and vice versa.

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5.1.3: Potential pollinators present in the study area

Out of 270 observed insect visitors only 33 insect pollinators were determined as potential pollinators of the 60 selected host plant species (Table 4.3.1.). The highest number of potential pollinators were from order Hymenoptera (22 species), followed by Lepidoptera (6 species), and Diptera (5 species), however no species were regarded as potential pollinators from Coleoptera order (Table 4.3.1.).

Hymenoptera representing highest number of potential pollinators (Table 4.3.1.) is supported by the findings of Sjodin (2007) where he considered bees (Apoidea) to be the most active flower visitors and probably also function as the most efficient group of pollinators; and van Dulmen (2001) (op. cit.) also supported this view by his findings that large bees and small bees are among the most important groups of pollinators. The reason might be due to the fact that these species are pollen and nectar feeders (Table 4.3.1.) and pollen and nectar are essential resources for bees because both are required for survival, and cannot be completely substituted for the other as reported by Plowright et al. (1993). Another reason for their efficiency in pollination may be due to their hairy bodies, good flight ability, and their variability in size, home range and specialization as claimed by Michener (2007).

The average number of Lepidopteran species representing potential pollinators may be due to the specificity in choice of resource plant species (Table 4.3.1.). Butterflies visit flower for nectar resources for maintenance and for reproductive activities (Naumann et al. 1999, and Franzen and Ranius, 2004) and they are also considered as most important pollinators for some specific plants like *Phlox divaricata* L., (Wiggam and Fergusan, 2005). The reason may be because of their long proboscis which gave easy access to narrow and long tube shaped flowers only while other insect groups were unable to reach the nectar source.

Only five Syrphid flies from Diptera order represented potential pollinators which may be due to the facts reported by Sjodin (2007) (op. cit.) that the smooth and light bodies of Dipteran species, their polyphagous pollen dependence (excepting Syrphid flies which were nectar feeders) and their small contact area with plant-sexual organs limited their ability to pollinate flowers.

The reason that beetles were not found to be potential pollinators in the present study (Table 4.3.1.) and were poor pollinators may be due to a number of factors like their limited flight ability, smooth bodies and low activity (Kevan and
Baker, 1983), and their phytophagous habit which at most times destroys the reproductive parts of the flower while feeding upon it. Another reason for their very low records as potential pollinators may be the absence of the mast flower species (mostly pollinated by beetles) which occur in a short, irregularly occurring ‘boom’ of which dipterocarp forests are famous as reported by van Dulmen (2001) (op. cit.).

Relative abundance was recorded highest in *Apis dorsata* followed by *Apis cerana* from the 40 pollinator insect species whose RA ≥ 5 at the visitor behaviour decision level 2 (Table 4.3.1.). Visitation rate was also recorded highest in *A. dorsata* followed by *A. cerana* from the 30 species whose VR ≥ 40 at the decision level 3 (Table 4.3.1.). Similarly, Neli and Kalita (2013) reported *Apis cerana* with the highest visitation rate of *Caesalpinia crista*. *A. cerana* and *A. dorsata* were also recorded with the highest number of flowers foraged per minute from the 55 species with record of ≥ 5 mean number of flowers foraged per minute (Table 4.3.1). Similar records were reported by Neli and Kalita (2013) (op. cit.). The reason for recording *A. dorsata* and *A. cerana* as the highest at the three visitor behaviour decision levels may be due to the fact that these insect species are always active social bees and are considered as primary and principal pollinators of many crops as reported by Free (1993) and Delaney and Tarpy (2008). Five insect visitors (*A. dorsata, Xylocopa aestuans, X. latipes, Xylocopa* sp. and *Augochlora pura*) were recorded with highest PD percentage ≥ 80 (Table 4.3.1.). Similar results were reported by Li et al. (2004) with highest PD percentage recorded in *Xylocopa* sp. visiting *Caesalpinia crista*.

The most abundant visitors like *Hylaeus* sp. 3, *Osmia* sp., *Polistes sagittarius*, *Zeneros flegyas*, *Jamides celeno*, *Junonia atlitae*, *Junonia almana*, *Junonia lemonias*, *Neptis hordonia*, *Terias hecabe*, *Elmnias hypermnestra*, *Orthellia claripennis*, *Musca* sp., *Phytomia zonata*, *Baccha sapphirina*, and *Allograpta javana* (Table 4.3.1.) and high frequent visitors with high visitation rates like *Vespa orientalis*, *Chrysis* sp., *Chalchid* sp. 1, and 2, *Apidae* sp. 1, and *Andrena cettii* (Table 4.3.1.) were not even potential pollinators of the selected plant community as observed in the present study. However, the least abundant visitors like *Amegilla cingulata, Ceratina smaragdula, Trigona* sp., *Xylocopa aestuans, Xylocopa latipes, Xylocopa* sp., *Anthidium* sp., and *Euploea core* (Table 4.3.1.) and less frequent visitors with less visitation rates like *Xanthogramma* sp., *Dideopsis aegrotus, Eristalinus arvorum, Episyrphus balteatus, Catopsilia pomona, Catopsilia pyranthe, Papilio polytes, Megachile lanata, and Trigona* sp. (Table 4.3.1.) were found to be potential pollinators. Blair and
Williamson (2008) also reported that the less common visitor *Diadasia rinconis* (Hymenoptera: Apidae) as the most effective and important pollinator over the most common visitor, *Macrotera lobata* (Hymenoptera: Andrenidae). Therefore, the hypothesis that the most abundant and frequent visitors are the most efficient and potential pollinators of the entire plant community cannot be accepted, even though a majority of plant species in a community are pollinated by the most abundant and frequent visitors and also the fact that every plant species has their own choice of pollinator species (pollinator specificity) proved the hypothesis otherwise.

The most important and efficient pollinator species (from the 33 potent pollinators recorded) of the selected plant community was found to be *Apis dorsata* followed by *Apis cerana* when all the five decision levels were considered (Table 4.3.1. and Fig. 4.3.1.). Similar records were reported by Neli *et al.* (2011) in *Acacia concinna* and Sjodin (2007) and van Dulmen (2001) (*op. cit.*). However, if only PD percentage was considered, *Xylocopa aestuans* and *X. latipes* were found to be the most efficient and important pollinators of the plant community (Table 4.3.1.). Similar result was obtained by Li *et al.* (2004) (*op. cit.*) in *Caesalpinia crista*.

5.1.4: Pollination biology of potential pollinators

Most potential pollinators were found to have a clear peak of activity in the 1000 - 1100 hr in the morning and 1500 - 1600 hr in the afternoon, and are very scarce after 1700 hr (Table 4.4.2.), were similar with the findings of Vicens and Bosch (2000b). Visitation time of pollinator insects, generally occur in the morning (Table 4.4.2.), related to plant resources, especially pollen and nectar availability which are higher in the morning than in the afternoon and evening as stated by Atmowidi *et al.* (2007). Visitation rates of potential pollinators were also recorded to be influenced by the passing of time during observation days (Table 4.4.2.). During noon time they were not seen on the flowers possibly because of high prevailing temperature. Although, intensities of pollinator visits declined with decreased plant densities, their patterns *i.e.*, temperature dependent initiation of visits, periods of peak visits and decline did not get upset as stated by Mishra *et al.* (2004) and similarly recorded in the present study. The highest length of visit per flower was recorded in butterflies (Table 4.4.2.) with similar records reported by Rianti *et al.* (2010). However, bees were recorded with the shortest length of visit per flower (Table 133).
4.4.3.) also similarly reported by Rianti et al. (2010) (op. cit.), collecting as much pollen as possible from the good number of flowers within a short period and quickly taking the next foraging visit. This may be the reason for considering them as the most efficient pollinators among the diverse insect fauna of pollinators. Flies subsequently groomed their head and eyes with their forelegs while feeding and very few pollen grains were retained on their body for cross-pollination. This might be the reason for their low records in PD% and their efficiency (Table 4.3.1.).

Differences in visitor activity (decision level 1) (Table 4.4.3.) were best explained by types of resources available. And differences in visitor activity diversity were also related to flower abundance (Sjodin, 2007) (op. cit.). Differences in the relative abundance of the pollinators (Decision level 2) (Table 4.4.3.) were based on the differences in the number of flowers in bloom. Abundance of pollinator insects increased during flowering season with the highest record in Summer and Spring seasons in the study area (Fig 4.4.2., 4.4.3., 4.4.4., 4.4.5., 4.4.6.) and similar records were reported by Kandori (2002) and Hegland and Totland (2005) in temperate grassland. The number of flowers may reflect the amount of reward for visitors and they seemed to be good at estimating the amount of resources on this scale (Dreisig, 1995).

All the potential pollinators were found to be generalist feeders (Table 4.4.1.). Despite the joint requirement and the concurrent production of pollen and nectar by many plant species, bees do not often collect pollen and nectar simultaneously (Atmowidi et al. 2007) (op. cit.) as also recorded in the study. This behaviour implies that the criteria affecting preferences for plant species depend on whether pollen or nectar is the focus of a bee’s foraging visit (Rasheed and Harder, 1997). Nectar resources diversity is not the only factor that is important in structuring communities of pollinator insects (Potts et al., 2004). Several other important components are the flower morphology (Neal et al., 1998) and the combination of sugars in the nectar (Hainsworth and Hamill, 1993). In the present study, most of the long tongued bees, and butterflies of the potential pollinator species were found to be visiting tube-shaped flowers. Insect proboscis length was recorded to be positively and significantly correlated with only gullet and tube shaped flower types (Table 4.4.4.). The reason for this may be due to the probability of many plant species hiding their floral rewards within flowers so that only insects with proboscis which in length roughly matches the depth of the corolla can efficiently extract nectar (Inouye, 1978,
Insect VR and RA were recorded to have positive significant correlations with the head, umbel, brush and umbel-head shaped flower types which signify that with the increase in number of these flower types their VR and RA also increased (Table 4.4.4.). In addition to these flower types gullet shaped flower type was also positively significantly correlated with insect RA (Table 4.4.4.). Social bees were recorded to prefer cluster and composite flowers (Table 4.4.1.) where they can obtain as much pollen from a single visit without spending much time and energy in search of the next flower with similar results reported by Fontaine et al. (2006). Since flies with shorter tongue do not probe deep and feed on exposed nectar, they usually prefer cymose umbelloid inflorescence (Mishra et al., 2004) (op. cit.). However, in certain cases, pollinators like: Xylocopa aestuans and X. latipes while visiting flowers of Tecoma stans, pierced a hole at the base of the flower and extracted nectar, hence they became nectar thieves for this plant just because this flower could not accommodate their entry due to their large body size which is supported by the findings of Momose et al. (1998) (op. cit.).

Bees of genus Amegilla which are Amegilla cingulata, Amegilla confusa, Amegilla zonata while visiting flowers were recorded to buzz and force open the intact anthers wasting the good amount of pollen before anthesis and stigma reception. Similar findings were reported by Martins (2008) where he reported on four pollinators species of Amegilla sp. visiting Saintpaulia teitensis showing distinctive floral manipulation (buzz pollination) for release of pollen. Hylaeus sp. 1 were observed forming bubble of nectar after collecting from Clerodendron viscosum flower for drying in the Sunlight as because the nectar is available in the diluted form. Megachilidae bees consistently contacted the anthers and stigma when landing on the flowers and females sometimes appeared to masticate the anthers, perhaps to obtain additional pollen, then they groomed with their fore- and mid- legs either on the floral bract or on the ground, and transferred the pollen into the ventral scopa. Their activities may be the reason for which they are considered as consistent pollinators.

Trees like Dillenia pentagynna, Dillenia indica, Mangifera indica, Ficus sp., Citrus grandis etc. were recorded as nest plants of the potential pollinators in the study area. It was observed that most of solitary bees built nest outside the dense forest, with similar records reported by Atmowidi et al. (2007) (op. cit.) adding the reason for bees building nest outside dense forest preferring less shaded and less humid agro-ecosystem that offered open areas for the many ground-nesting species.
and herbaceous plants for pollen and nectar resources. However, Klein et al. (2002) reported that solitary bees profited from land-use intensity, because increasing land-use intensity led to more nesting sites for ground-nesting solitary bees. Atmowidi et al. (2007) (op. cit.) reported that most of social bees were found in higher densities within and near the forest than at greater distance from forest, presumably because forest offers a wealth of suitable nesting sites for the colonies of honey bees and stingless bees foraging into the adjacent land-use system. These types of nest plant species and nesting sites which fulfil the habitat requirements of the potential pollinators are important in addition to their nectar and pollen plant species (Table 4.4.1.).

5.1.5: Abiotic and biotic factors affecting the potential pollinators

The most important determinant for insect diversity, abundance and foraging activities are climatic conditions (Kevan and Baker, 1983) (op. cit.) and availability of food (Aizen and Feisinger, 1994, and Mustajarvi et al., 2001). The correlation of insect species like Amegilla confusa, Anthophora sp., Anthidium sp. and Eristalinus arvorum with temperature were found to be positively significant whereas species like Megachile carbonaria, Catopsilia pomona, Xanthogramma sp. was negatively and significantly correlated with temperature (Table 4.5.1.). Correlation of overall insect abundance was found to be positively significant with temperature (Table 4.5.1.). Similar observations were reported by Bergman et al. (1996), Vicens and Bosch (2000b) (op. cit.), Wall et al. (2003), Wikstrom et al. (2009) where temperature played significant role in affecting insect abundance. The pollinator activity initiation is reported to be limited by temperature, and activity termination is determined either by a decline in light intensity or, possibly, by a decline in pollen-nectar availability (Lerer et al., 1982; Abrol and Kapil, 1986; Abrol, 1988). Williams and Williams (1983) also reported that temperature can have considerable influence on pollinator systems, both by affecting the activity of insects or by altering the volatilization of attractants and nectar flow.

Except six species, the potential pollinators were found to be significantly and negatively correlated with RH (Table 4.5.1.). RH was found to be with high significant negative correlation with the overall potential pollinators (Table 4.5.1.) which signify that with the increase of RH, the potential pollinators decrease highly in
abundance and activities. All potential pollinators showed activities at relative humidity below 90% which was similarly reported by Vicens and Bosch (2000b) (op. cit.).

Wind speed was recorded with high significant positive correlation with overall potential pollinators (Table 4.5.1.). As already mentioned high wind velocities causes navigation problems, particularly to small insects (Unwin and Corbet, 1991), however, larger and hardy pollinators like bumblebees were often seen flying in windy conditions and may be adapted to high wind speeds as reported by Bergman et al. (1996) (op. cit.) but the wind speed never exceeded 10 m/s. In case of the present study, insect pollinators were not recorded when the wind speed exceeded 8 km/hr (1 km/hr equals 0.278 m/s) which means that wind speed had significant positive effects on the studied pollinators till 8 km/hr but more than 8 km/hr it had significant inhibitory effects on them. Similarly, Eisikowitch and Galil (1971) also reported that insects perform effective pollination flights only when wind speed does not exceed 2 - 2.5 m/s (7.2 - 9 km/hr).

No significant correlation was recorded between potential pollinators and rainfall (Table 4.5.1.). However, the potential pollinators were not recorded at high rainfall condition (> 200 mm). In contrast Murali (1993) reported that rainfall had significant effects on the flower success patterns of two plant species where canopy tree Gmelina arborea was benefited than understorey Cassia fistula due to pollinator limitation of C. fistula in the wet site and because of its shading by the G. arborea.

The most significant finding of the study is that potential pollinator abundance correlation with plant abundance was highly positively significant and pollinator abundance and richness decreases with the decrease in plant density (Table 4.5.1.). Similar records were reported by Aizen and Feisinger (1994) (op. cit.), Mustajarvi et al. (2001) (op. cit.), Bosch and Waser (1999), Feisinger et al. (1991) and Kunin (1997). Comparatively, higher numbers of pollinator species were recorded on dense plants to be followed by intermediate and isolated plants (Table 4.5.1.). Similarly, Mishra et al. (2004) (op. cit.) also recorded that maximum number of pollinator species visited the dense plants of Zizyphus mauritiana, as compared to intermediate and isolated plant which clearly showed a significant effect of plant density on species composition of the visitor community. Larger populations of plants are likely to be more attractive to pollinators resulting in higher visitation rate and therefore pollination success (Agren, 1996, Sih and Baltus, 1987), and small populations may
suffer from insufficient pollen transfer and consequently lower seeds set (Fischer and Matthies, 1998, and Lamont et al., 1993). Veddeler et al. (2006) added to this thought that dense flower patches seem to be the more attractive resource for many different bee species at smaller spatial scales. In *Phacelia* sp., Westphal et al. (2006) also reported that mass-flowering fields represent more rewarding resources and bumblebees could collect more rewards per unit time than the ones in the environments with sparse resources, which presumably had longer search and travel times. However, Optimal foraging theory (Charnov, 1976) predicts that in sparse populations, pollinators switch over will be less between plants and visit more flowers within the same plant when plant density is low as agreed by Cresswell (1997), Heinrich (1979), Klinkhamer and de Jong (1990).

In the present study, potential pollinators were recorded to be lowest in HD habitat (25/33 potential pollinator species and 1494 individual numbers only) (Table 4.5.1.). Similarly, Eremeeva and Sushchev (2005) found that rare and very rare pollinator species were reduced in urban landscapes with the decrease in the number of wild food plants and destruction of their nests. Jana et al. (2012) as already mentioned that anthropogenic disturbance, probably due to industrial emissions has changed the compositions and structures of the insect communities.

They were also recorded to be sensitive to changes in abiotic factors like temperature, relative humidity, wind speed and rainfall (Table 4.5.1.). Similarly, Vicens and Bosch (2000b) (op. cit.) reported that unfavorable weather conditions reduced the pollinator activity and lowered pollinator number in apple orchard. The potent pollinators were also recorded to be sensitive to biotic factors like abundance and richness of resource plant species and human disturbances (Fig 4.5.1.). Hence, these potent pollinators can be considered as indicator species of the forest health condition of the study area. In can be addressed that this finding indicated that the HD habitat is deteriorating as compared to MD and UD habitat. The populations of potential pollinator species as well as the corresponding plant species are at risks in the HD habitat.