Home Insects : Important Representatives of the Diversity around us

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Introduction

Observations and sporadic photographic data gathering of insects and the garden around my house inspired me to write this note, "Home Insects". However since I don't have a background of formal Biological science, major contribution in interpreting and analyzing data is by co-author Aditi Kale.

Why Study Insect Diversity?

Significant insect diversity was encountered around the house. Documentation of this diversity was started and photographic data generated whenever possible. While documenting, I tried to identify insects and read more about the taxa.

Insects (Class Insecta) are one of the most diverse group on earth. They have successfully adapted to various landscapes and habitats and also have various important ecological roles like pollinators, prey and predators. They utilize various resources in their surroundings to complete their life-cycle successfully. Hence, species richness and abundance of insect diversity are strongly related to the ecological balance in the areas they occupy.

There is a general consensus that there is a decline in insect population all over the world. Given the important role they play in ecology, research regarding causes of decline in insect population is also a priority subject. (Ref: Yale Environment, <http://e360.yale.edu>) The common causes of insect population decline are intense agriculture, urbanization and fragmentation of ecosystems.

Original ecosystem is fragmented into dispersed wilderness patches due to urban development. The space between these wilderness patches is called a matrix. This situation calls for examining the effect of urbanization by gathering insect data in this urban matrix area.

There are studies regarding matrix area in the urban landscape and agricultural landscape. These studies give guideline for the documentation of insects in the matrix area of urban as well as agricultural landscape.

"Much of the focus on biodiversity within agricultural landscapes has been on the conservation of rare species. But recently another issue has become equally prominent, namely whether or not increased biodiversity or species richness enhances ecosystem functions such as primary productivity and nutrient retention or ecosystem services such as pollination and biological control." (Daily, 1997; Tilman, 1997; Hector et al., 1999; Kaiser, 2000; Loreau, 2000)

For this reason the diversity of common and widespread species also becomes important.

The importance of garden habitat in the urban area is also stressed by A.J. Bates and others (Ref. Jan 2014 Vol. 9 Issue 1/e86925, www.plosone.org). In their study, "Effects of Urbanization and Habitat Diversity with moth's conservation status," they state that "there is a consistent trend in species richness and total moth abundance; gardens with more diverse and extensive microhabitats were associated with higher species richness and moth abundance."

However, such studies are few and so there is a need to examine the situation in tropical urban areas, particularly in the matrix. Collection of data in such areas will add to the larger data bank.

Location

The house and the garden (See Map 1 : home) are located in the northern vicinity of 'Vetal Hill Complex' wilderness. (See Map 1 : 2) It is approximately one half kilometre distance away as crow flies. Top of the hill complex is the wilderness area, though large part of it is under plantation of non native trees. Another wilderness areas close by are NCL campus

Map 1 : Location Map

(See Map 1 : 1) and the Pashan lake and its surroundings. These wilderness areas are surrounded by growth of the city housing and the road network. On its northern direction the housing is of a bungalow type. Most of these bungalows have gardens and some open spaces.

The site of insect observations has its own peculiarities. Though the site is situated in urban area, it is not a part of dense construction. It has a semi-wilderness character. This semi-wilderness character is due to purposeful decision of not to have a manicured garden. The adjacent bungalows have manicured gar-

dens with the use of chemical fertilizers and insecticides.

Materials and Methods

Notebook and camera are the main materials used. Since many insects are difficult to identify in the field, camera becomes most essential tool for record. The other observations such as activities like foraging, egg laying, nectar gathering, nesting, etc. were noted down. The association of a particular species of insect with a habitat was observed. Recurrence of same species was also noted. Identified insects not recorded

with photographs have also been included in the final list of observations.

A Sony Digital Camera was used for capturing photos of the insects. It was helpful in recording different life stages like larva, pupa and emerging adults of species like Brown Awl Skipper. Some activities like foraging on host plants, pollen and nectar gathering, and mating were also recorded using camera.

A few books were used for identification (Reference Books list is provided). Sometimes there were unexpected, unusual sightings. To identify such sightings, help of experts was taken. e. g. Tree Hopper or unidentified morph of a Moth. Butterflies were identified using few books, encyclopaedia and the website "I Found Butterfly" was used.

Identification of Habitats

Observing and taking photographs led to the realization that certain insects have an association with a particular place in the garden. Thus, by looking carefully and observing their activities, the variations or habitats in the garden were indentified.

The garden has got the following micro-habitats which suffice different needs of different insects.

1. Garden waste decomposition pit
2. Tall tree canopy with shady area
3. Wet mud spot
4. Sand flat
5. Terrace kitchen garden
6. Small patches of formal non-native lawn
7. Shrub clusters
8. Natural grass patch at the back of the plot where very little disturbance may occur

The grass patch is a very important habitat which has got lot of variety of natural grasses and herbs. The species of grasses succeed from early monsoon to late monsoon rains. And this habitat has a maximum diversity of small-sized insects.

Observations

1. Diversity of Insects and Plants

The total diversity encountered in the garden as well as inside the house is represented in the table 1. The insects were identified up to Order level and were further classified into morphospecies (distinct taxa identified easily on the basis of evident morphological traits). The species in the premises, thus recorded, were around 145 representing 11 insect Orders.

The table 1 shows that the maximum diversity is of Order Lepidoptera, including Moths, Skippers and

Table 1 : Classification according to order of the taxa

Order	Number
Coleoptera	10
Dermaptera	1
Diptera	7
Hemiptera	10
Homoptera	3
Hymenoptera	18
Lepidoptera	80+
Mantodea	1
Neuroptera	1
Odonata	5
Orthoptera	4

Butterflies. The number of Butterfly species was almost equivalent to overall Moth species diversity. However, observations of activities of butterflies are much more. Moth behaviour was difficult to observe because of their nocturnal activity.

The second most abundant insects after Lepidoptera were Order Hymenoptera i. e. Bees and Wasps. Wasps, especially, use various niches like grills and window sills for nesting. Bugs and Beetles (Hemiptera and Coloeoptera) are the two other abundant Orders. Some small beetle species complete their lifecycle on small shrubs like *Plumbago auriculata* and an Elateridae beetle has infested the Mango (*Mangifera indica*) tree.

The study site garden has a combination of native and some few non native species. The number of tree species is much greater than shrubs, herbs and climbers. The ratio is 22:14:7:4. A detailed list of the species present in the garden is given in the table 2.

Some of the trees are slightly different than the usual horticultural varieties which are planted in gardens. To name the few, *Pterygota alata* (Roxb) R. Br. or Budha Coconut of Malvaceae family and *Bombax ceiba* L. of the same Malvaceae family which are usually seen in the wild. Another special tree is a palm species (which I was unable to identify). Among the non – native *Senna siamea* or Kashid and *Couroupita guianensis* or Kailaspati are prominent. However they are said to be Indianized and accepted by birds and insects.

Table 2 : List of plants

Sr. No.	Local Name	Scientific name	Family	Flowering season
		Trees		
1	Buddha Coconut	<i>Pterygota alata</i> (Roxb.) R.Br.	Malvaceae	Feb
2	All spice	<i>Pimenta dioica</i> (L.) Merr.	Myrtaceae	
3	Amba	<i>Mangifera indica</i> L.	Anacardiaceae	Jan-Feb
4	Bahava	<i>Cassia fistula</i> L.	Leguminosae	Apr-May
5	Bakul	<i>Mimusops elengi</i> L.	Sapotaceae	Feb
6	Chandan	<i>Santalum album</i> L.	Santalaceae	July-Aug
7	Chikoo	<i>Manilkara zapota</i> (L.) P.Royen	Sapotaceae	
8	Kadamb	<i>Neolamarckia cadamba</i> (Roxb.) Bosser	Rubiaceae	July
9	Kadhipatta	<i>Murraya koenigii</i> (L.) Spreng.	Rutaceae	Mar
10	Kailaspati	<i>Couroupita guianensis</i> Aubl.	Lecythidaceae	Oct
11	Kashid	<i>Senna siamea</i> (Lam.) H.S.Irwin & Barneby	Leguminosae	Aug-May
12	Katesawar	<i>Bombax ceiba</i> L.	Malvaceae	Feb-March
13	Naral	<i>Cocos nucifera</i> L.	Arecaceae	All
14	Palas	<i>Butea monosperma</i> (Lam.) Taub.	Leguminosae	Jan-Feb
15	Palm	Palm sp.	Arecaceae	
16	Pandhara Chafa	<i>Plumeria obtusa</i> L.	Apocynaceae	Apr-May
17	Seetaphal	<i>Annona squamosa</i> L.	Annonaceae	May
18	Sonchafa	<i>Magnolia champaca</i> (L.) Baill. ex Pierre	Magnoliaceae	Mar-Apr
19	Tabebuiea	<i>Tabebuiea</i> sp.	Bignoniaceae	Mar
20	Taman	<i>Lagerstroemia speciosa</i> (L.) Pers.	Lythraceae	May-June
21	Thorel's Crape Myrtle	<i>Lagerstroemia thorelii</i> Gagnep.	Lythraceae	Oct-Nov
22	Tuti	<i>Morus alba</i> L.	Moraceae-	Feb
		Herbs		
1	Broom grass	<i>Thysanolaena latifolia</i> (Roxb. ex Hornem.) Honda	Poaceae	Mar-June
2	Ekdandi	<i>Tridax procumbens</i> (L.) L.	Compositae	All
3	Gavati chaha	<i>Cymbopogon citratus</i> (DC.) Stapf	Poaceae	Oct-Nov
4	Kardal	<i>Canna indica</i> L.	Cannaceae	Sept
5	Khulkhula	<i>Crotalaria retusa</i> L.	Leguminosae	Oct
6	Ova	<i>Plectranthus amboinicus</i> (Lour.) Spreng.	Lamiaceae	Oct-Nov
7	Terada	<i>Impatiens balsamina</i> L.	Balsaminaceae	Aug-Sept

Sr. No.	Local Name	Scientific name	Family	Flowering season
		Shrubs		
1	Adulasa	<i>Justicia adhatoda</i> L.	Acanthaceae	Dec
2	Anant	<i>Gardenia jasminoides</i> J.Ellis	Rubiaceae	July
3	Brahmkamal	<i>Epiphyllum oxypetalum</i> (DC.) Haw.	Cactaceae	August
4	Fire Bush	<i>Hamelia patens</i> Jacq.	Rubiaceae	Dec
5	Ixora	<i>Ixora</i> sp.	Rubiaceae	Aug-Oct
6	Jaswand	<i>Hibiscus rosa-sinensis</i> L.	Malvaceae	All
7	Karvand	<i>Carissa carandas</i> L.	Apocynaceae	Feb-March
8	Kavathi chafa	<i>Magnolia coco</i> (Lour.) DC.	Magnoliaceae	April
9	Hirva chafa	<i>Artabotrys hexapetalus</i> (L. f.) Bhandari	Magnoliaceae	April
10	Mogara	<i>Jasminum sambac</i> var. 'Maid of Orleans'	Oleaceae	May
11	Pivala Kanchan	<i>Bauhinia tomentosa</i> L.	Leguminosae	Dec
12	Powder puff	<i>Calliandra haematocephala</i> Hassk.	Leguminosae	Dec
13	Ratrani	<i>Cestrum nocturnum</i> L.	Solanaceae	Jan-June
14	Sandpaper Vine	<i>Petrea volubilis</i> L.	Verbenaceae	Jan-Feb
		Climbers		
1	Hoya	<i>Hoya</i> sp.	Apocynaceae	May
2	Jai	<i>Jasminum grandiflorum</i> L.	Oleaceae	Aug-Sept
3	Madhavilata	<i>Hiptage benghalensis</i> (L.) Kurz	Malpighiaceae	Oct
4	Vidhyache pan	<i>Piper betle</i> L.	Piperacaceae	

Some frequently observed insect activities included- Common Emigrant butterflies visit the garden in large numbers, but they rarely come down for foraging. Various forms of evening browns are common and numerous and they are seen almost throughout the year.

Four species of skippers viz Brown Awl, Indian Palm Bob, Canara Swift and Grass Demon add to the diversity of the garden. Out of these four, two, Grass Demon and Brown Awl complete their life cycle on *Hedychium coronarium* (Family Zingiberaceae) or Sontakka and *Hiptage benghalensis* (Madhavilata) respectively. I have been observing Canara Swift since 2011 and it is a regular visitor, but I could not observe its life cycle. On the other hand, Brown Awl is a relatively new addition ever since the introduction of *Hiptage benghalensis* four years back.

Moths can be categorized into two types : the small

sized seen almost throughout the year, residents of natural grass patch, potted shrubs and shrub thickets, and same species are repeated throughout the year. The big size moths are of great variety. However very rarely these species are repeated. Exception is of Owl moth and *Micronia aculeata* (white lacy in appearance).

The most common and numerous species observed throughout the year are Blue butterflies and small sized moths.

Dendropathoe falcata (Lorenthus) has grown on *Lagarstroemia thorelli*. As described in the book "A Guide to the Butterflies of the Western Ghats, by Milind Bhakre & Hemant Ogale", it hosts Common Jezebel, Gaudy Baron and Peacock Royal butterflies. Out of these, partial life cycle of Gaudy Baron was observed (only larva stage and butterfly) in the garden.

Table 3 : List of Butterflies

Family Papilionidae (Swallowtails)	
Common Rose	<i>Patchliopta aristolochiae</i> Fabricius
Common Jay	<i>Graphium dosen</i> C & R Felder
Tailed Jay	<i>Graphium agamemnon</i> Linnaeus
Common Mormon	<i>Papilio polytes</i> Linnaeus
Great Jay	<i>Graphium eurypylus</i> Linnaeus
Family Pieridae (Whites and Yellows)	
One Spot Grass	
Three Spot Grass Yellow	<i>Eurema blanda</i> Boisduval
Common Jezebl	<i>Delias eucharis</i> Drury
Common Emigrant (Both Dry & Wet Form)	<i>Catopsilia pomona</i> Fabricius
Family Nymphalidae (Brush footed)	
Common Evening Brown Wet Season Dark, Dry Season	<i>Melanitis leda</i> Linnaeus
Common Five Ring	<i>Ypthima baladus</i> Fabricius
Common Sailer	<i>Neptis hylas</i> Moore
Common Baron and male	<i>Euthalia aconthea</i> Cramer
Great Egg fly (Female) Wet form	<i>Hypolimnys bolina</i> Linnaeus
Gaudy Baron	<i>Euthalia lubentina</i> Cramer
Family Lycaenidae (Blues)	
Red Pierrot	<i>Talioda myseus</i> Guerin Meneville
Zebra Blue	<i>Leptotes plinius</i> Fabricius
Tiny Grass Blue	<i>Zizula hylaso</i> Fabricius
Pea Blue	<i>Lampides boeticus</i> Linnaeus
Pale Grass Blue	<i>Pseudozizeeria moha</i> <i>Eurema anderssoni</i>
Lesser Grass Blue	<i>Zizina otis</i> Fabricius
Forget me Not	<i>Catochrysops strabo</i> (Fabricius)
Common Cerulean	<i>Jamides celeno</i> Cramer
Pains Cupid	<i>Luthrodes pandava</i>
Slate Flash	<i>Rapala manea</i> Hewitson 1863 <i>Rapala manea</i> Schistacea Moore 1879
Family Hesperidae (Skippers)	
Grass Demon	<i>Udasper folus</i> Cramer
Indian Palm Bob (common Grass Dart)	<i>Suastus gremius</i> (Fabricius)
Canara Swift	<i>Caltois canaraica</i>
Brown Awl	<i>Badamia exclamattionis</i> (Fabricius)

The species richness in general and abundance of some species in particular is related to diverse microhabitats. A small area like a garden shows almost eight microhabitats and species richness greater than 145 species. Some species like small sized moths and common emigrants are abundant.

This observation is corroborated by the following studies : “We found that associations with habitat and landscape composition were species-specific, but there were consistent trends in species richness and total moth abundance; Gardens with more diverse and extensive microhabitats were associated with higher species richness and moth abundance” (Ref. A.J. Bates and others : Garden and Landscape-scale correlates Jan 2014, Vol. 9 Issue 1, e86925, www.plosone.org.)

The other study of species richness in agro-ecosystems has similar findings and states : “The species richness generally increased with landscape heterogeneity on a farm scale. Habitat type had a major effect on the species richness for most groups, with most species found in pastures and lays” (Ref. Ann-Christin Weibull, Orjan Ostman and Asa Granqvist, “Species Richness in Agrosystems: the effect of landscape habitat and farm management, Biodiversity Conservation 12 1335-1355, 2003)

Ichneumon Wasps are also numerous; reason maybe they play an important role as biocontrol agent by parasitizing Lepidopteran larvae or eggs. Lepidoptera species were maximum in the garden.

2. Relations between Habitat Diversity and Insect Diversity

Habitats used by specific insects

Certain habitats are utilized by a particular set of insects. The natural grass patch with seasonal wild herbs was found used by Damselflies. Observation of three species of Damselflies indicate that they are always seen gliding through short natural grass. They were rarely seen using other micro-habitats. Similarly, small sized varieties of ‘Blues’, namely pale grass blue, tiny grass blue, Lesser Grass Blue use this natural grass habitat. These blues are also rarely seen using other micro-habitats. The Common Baron Female is always in the vicinity of the mango tree; many times observed basking in the sun on mango leaves. (Ref. Peter Smetacek 2017, A Naturalist’s Guide to the Butterflies of India.)

Habitats used by several species

The grass patch, which is natural growth of grasses

and seasonal herbs, shows maximum diversity of insects. Damselflies of 3 types and Dragonflies of 2 types were observed here. They visit for prey as this grassy patch hosts ants, various moth species and several butterflies like blues and yellows that visit herbs like *Tridax*, *Vernonia cineraria*. Damselflies glide in the stands of short grass.

The smaller sized moths are found in abundance and take refuge behind or perch on the underside of the grass blades. Honeybees also get attracted to the seasonal herbs mentioned above for nectar. Bordering the grassy patch are small shrubs which support a few beetle species. A few beetles and grasshoppers were also encountered in this patch.

Insects found across different habitats

Though ‘Blues’ and ‘Grass Yellows’ butterflies use grassy patch habitat, they also use other habitats. The flowers of ‘Jasmine’ climber are regularly visited by Blues. Butterflies also use the wet mud habitat near the tap and the kitchen garden on terrace and Blues and Female barons are commonly observed.

Shrubs and Climbers are used by specific species of butterflies to complete their lifecycle. But after the adults emerge, they use various habitats. For example, Brown Awl’s lifecycle is completed on ‘*Hiptage*’ climber but once it is on wing, it uses almost all habitats including the grass patch.

3. Relation between Vegetation and Insect type

There are trees and tree canopy in a part of the garden. Tree trunks are commonly used by Cicadas for perching. Tree canopy is always a favourite place for bigger Butterflies like Tailed Jay, Common Jezebel, Common Rose, etc.

There is a Loranthaceae Family member growing on *Lagerstroemia thorelli*. The larvae and adult of ‘Gaudy Baron’ butterfly were observed and photographed in the vicinity of this plant, which is a known host plant for this butterfly.

The shrub clusters and climbers also make another habitat for insects. Shrub cluster of *Hedygium caronarium* (Sontakka) supports complete lifecycle of a skipper ‘Grass Demon’. I have seen successful life cycles of Grass Demon at least for four years. Another close association observed is of skipper ‘Brown Awl’ for the last two years. I have been observing larva, pupa and the butterfly stages of Brown Awl on *Hiptage*.

A significant diversity of pollinators like Lepidoptera and Hymenoptera shows that these pollinators get enough nectar and pollens from the

vegetation. Thus different types and stages of the vegetation provides for different needs of these insects including feeding, mating and resting.

4. Relations with other Taxa

Birds

There are about 26 different species of birds, some visiting and some resident, in the garden (Table 4). Out of these 26 species, 25 of the bird species are

insectivorous. This indicates a strong prey-predator relationship. Insect population must be enough to support all these varieties of birds.

Another association observed is that of the habitat of decomposition pit shared by varieties of flies and Tickell's Blue Flycatcher. There are two types of Flycatchers, Tickell's Blue and Fantail Flycatcher, indicating a good population of flies and insects.

There is also a resident Spotted Owlet pair in the garden, residing on the palm tree. They commonly

Table 4 : List of Birds

1	Blue Rock Pigeon	<i>Columba livia</i>
2	Spotted Dove	<i>Streptopelia chinensis</i>
3	Little Brown Dove	<i>Streptopelia senegalensis</i>
4	Roseringed Parakeet	<i>Psittacula krameri</i>
5	Crow Pheasant or Coucal	<i>Centropus sinensis</i>
6	Koel	<i>Eudynamis scolopacea</i>
7	Spotted Owlet	<i>Athene brama</i>
8	Common Grey Hornbill	<i>Ocyrocus birostris</i>
9	Crimson breasted Barbet	<i>Megalaima haemacephala</i>
10	Golden Oriole	<i>Oriolus oriolus</i>
11	Indian Myna	<i>Acridotheres tristis</i>
12	Red vented Bulbul	<i>Pycnonotus cafer</i>
13	White cheeked Bulbul	<i>Pycnonotus leucogenys</i>
14	Tickell's Blue Flycatcher	<i>Cyornis tickelliae</i>
15	White spotted Fantail Flycatcher	<i>Rhipidura albicollis</i>
16	Ashy wren Warbler	<i>Prinia socialis</i>
17	Tailor Bird	<i>Orthotomus sutorius</i>
18	Magpie Robin	<i>Copsychus saularis</i>
19	Indian Robin	<i>Saxicoloides fulicatus</i>
20	Grey Tit	<i>Parus major</i>
21	Thick billed Flower Pecker	<i>Dicaeum agile</i>
22	Tickell's Flower Pecker	<i>Dicaeum erythrorhynchos</i>
23	Purple rumped Sunbird	<i>Nectarinia zeylanica</i>
24	Purple Sunbird	<i>Nectarinia asiatica</i>
25	White Eye	<i>Zosterops palpebrosus</i>
26	Spotted Munia	<i>Lonchura malacca</i>

feed on Geckos. Geckos, in turn, are found in abundance due to availability of insect prey in the garden.

Bats and Bees

Both Wasps and Honeybees have nests in the garden. Though honeybees go long distances for foraging, their requirement for building nest along with some amount of flowering is provided by available vegetation.

Profuse flowering of Kadamba tree not only gives nectar to bees but it is also shared by bats. There are a few long-nosed bats taking refuge on the Kadamba tree and chewing off the flowers and flower balls are thrown on the ground.

Discussion

Broader Context of Landscape Ecology

The study site garden supports unusual species richness of insects. This makes a case to look at this small part of wilderness matrix in a broader context of landscape ecology to understand its importance and ecological value.

"Highly developed landscapes encompass a patchwork of small, highly fragmented patches of semi-natural or favourably managed habitats set within a matrix of intensively managed agricultural and urbanized areas. Within this landscape gardens can provide substantial habitat resources, especially for highly mobile species able to utilize resources from spatially fragmented habitats" (Westrich, 1996)

"Matrix is a habitat between patches of semi natural habitats. The matrix was considered as uniform and ecologically irrelevant. But now because of recent research it is evident that various Matrix types such as agriculture, urbanization etc. can act to provide resource availability and services like movement of pollinators, seed dispersal etc." (Jules and Shahani, 2003)

These two references of research papers talk about the importance of Matrix in ecological functioning, especially their role in the semi-natural patch dynamics. The study garden is a part of the Matrix with large variety of micro-habitats. It provides resources to many insects and a connect between Vetil Hill Complex and National Chemical Laboratory Campus wilderness.

Partial Habitat

The entire home range of an insect species is not covered at one site when the landscape is fragmented into patches and Matrix. The Matrix may consist of

several partial habitats. Partial habitats may not provide all resources needed by insect to complete the life cycle but each one is crucial to support some phase or need of the insect for its survival. For example, partial habitat may provide foraging area but not other requirement like nesting.

Partial habitats are usually divided by development activities such as road, railway tract construction etc. This may result in scattering of habitats in a wide space. If the scattered habitats are not close by, then they become practically unavailable to insects. This may lead to extinction of local populations.

Paul Westrich in his paper regarding honey bee habitat conservation says that, "But not all threatened bees can be conserved within nature reserves and not all of a given country side can be establish reserves. Therefore, we should implement programmes which encompass reserves as well as non-reserved habitats." The partial habitat quality is also important, especially to influence the availability of pollinators. The problems of partial habitats are : 1) insect pollinators require different habitats at different stages of their life cycle. 2) If matrix alteration takes place and it consists of more flowering plants, insects may not visit adjacent agricultural area and need of the agricultural crop will not be fulfilled. In case of other ecosystems role of insects in the matrix with the ecological dynamics of semi-natural patches will be restricted, resulting in less genetic diversity. (ref; Paul Westrich, 1996) This explains the importance of partial habitats in the Matrix.

Thus, the presence and distribution of partial habitats determine survival of insect population dependent on them. Partial habitats play an important role in landscape matrix. They may not serve all needs but are important to complete some phase of their life cycle and survival. Partial habitats become important for the following reasons.

- 1) Optimum distance between partial habitats is important. If the partial habitats are scattered and not close-by then they become practically unavailable to insects affecting local population of insect.
- 2) Quality of partial habitat available for use is important, as it decides existence, survival and population threshold of insects.
 - a) Quality of partial habitat will be beneficial to insects if habitats are natural and not manicured.
 - b) Use of chemical fertilizers and insecticide will have deleterious effect on insects.
 - c) Habitat quality also depends on the number and type of micro-habitats.
- 3) Inclusion of Partial habitats into the landscape is

necessary.

Matrix is an important aspect of urban ecology but its dynamics remain a challenge. Matrix is essential to maintain connectivity between fragmented wilderness patches. But in urban area matrix is altered for the development purposes and very small area remains as matrix. Hence efforts need to be undertaken to preserve and enhance matrix areas in urban landscapes.

Significance of semi-natural grass habitat

Unlike planted trees and shrubs, grass patch in the garden is completely natural. The wild grasses start growing with the monsoon. As monsoon advances, there is a change in the grass species and wild herbs. This part of the garden is unfrequented, and without any intervention. All these conditions favour insect diversity. There is maximum diversity of insects which resides in this habitat.

Approximately four varieties of small sized moths, two big size moths, one species is owl moth, one species of wasp, four species of small size 'blue' butterflies, two species of grass yellow butterflies, three species of damselflies, two species of bugs form species diversity of natural, non-manicured, grass habitat in the garden. This richness of species compared with the patch of lawn is much greater. The lawn with horticultural variety of *Paspalum* grass is visited only by four to five butterflies. Other insects, moths were rarely seen visiting lawn, indicating importance of natural habitats. It suggests that to support biodiversity in urban areas, there is a need to keep one corner of garden habitat in a natural state.

Conclusion

This study indicates role of surrounding habitats to support larger wilderness areas and acting as stepping stones for conserving local biodiversity.

Targeted efforts to protect and enhance habitat diversity and quality are needed in urban areas. And multi-taxa studies like these will help us to understand the local conditions that sustain urban wilderness and help in designing landscape restoration projects and biodiversity parks.

Advantage of this exercise is that solutions to enhance local diversity requires less effort and less investment as it is only benign neglect to allow the ecosystem to revive itself.

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Bug (Homoptera)

Moth (Lepidoptera)

Pale Grass Blue

Canara Swift

Common Hedge Blue

Honey Bee

Damselfly

One Spot Grass Yellow

Moth (Lepidoptera)

Damselfly

Damselfly

Moth (Lepidoptera)

Representative biodiversity in the natural grass patch

Lifecycle of Brown Awl on Hiptage benghalensis

Lifecycle of Grass Demon on Hedychium coronarium

Lifecycle of Gaudy Baron on Dendrothoe falcata (Lorentus)

The following link shows the total insect diversity photos in the study site :
<https://bit.ly/2UHauMB>