# Nocturnal Insect's Richness and Abundance in Gardens: A Review

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***Abstract-*** The term nocturnality refers to those insects which remain energetic during night time and remain less energetic during day time. They totally depend upon colour signals for hunting, courtship alignment and escaping from predator. Insects play an important role in ecosystem like, pollination, decomposition, nutrient cycling and aeration in soil. As the flowering season comes, the number of species belonged to different orders like Hymenoptera, Lepidoptera, Diptera and Coleoptera increases, because the members of these orders mostly stay in the flowers.

***Index Terms***- Abundance; Decomposition; Ecosystem; Nocturnal insects; Predator-prey relationship; Richness

## I. Introduction

Biodiversity can be defined as the variety of natural life and its abundance on the earth and contains differences at all stages of biological society. There are almost 13.5 million species present on the earth. The maximum number of species is approximately 111.5 million and minimum number of species is approximately 3.5 million (Gaston and Spicer, 2004)

Among the species, hexapods are the major group of invertebrates which belongs to phylum Arthropoda (Wilson, 2009). They have segmented body and exoskeleton. Their exoskeleton made up of chitin. Phylum Arthropoda comprises 24 orders, like Hymenoptera, Diptera, Coleoptera and Lepidoptera. They are more than half of the living organisms and play a major role in ecosystem sustainability (Stork *et al*., 2015).

### Nocturnality

The term Nocturnality can be defined as the organisms which remain energetic during night time and remain less energetic or remain sleepy during day time. The insects that show this behavior are called nocturnal insects. They totally depend upon color signals for hunting, courtship alignment and escaping from predators (Warrant, 1999). There are several techniques that are used to quantify the presence of nocturnal insects, e.g. light traps are basically used for attracting night-flying insects. The sources of light include fluorescent lamps, black lights, and light-producing diodes. Designs of the lights are different and depending upon the insect behavior. The light traps are used for analysis of nocturnal insects. Total species and amount of their abundance altered by certain factors i.e. night temperature, humidity and lamp type (Jonason *et al*., 2014).

### Floriculture

Floriculture is the chief branch of horticulture. Floriculture can be defined as the formation of ornamental plants in the ornamental gardens for visual determinations. Attractive plants help to form accommodation mats on the richness of the population of unlike cropping systems. Attractive plants help to decrease noise pollution, removing dust, reducing heat buildup and decreasing air pollution. They give us the places for our social exercises and for games. These contribute as emphasizers, attractors and have esthetics values for activities of humans. As the flowering season comes, the number of species (order Hymenoptera, Lepidoptera, Diptera and Coleoptera) increases because, the members of these orders mostly stay in the flowers (Ion *et al*., 2007; Jadhav *et al*., 2011).

### Importance of Insects

Insects play an important role in the ecosystem like pollination, decomposition, nutrient cycling, and aeration in the soil. There is great variety of ants and butterflies in the ornamental gardens, in the gardens of homes, trees and small plants that give shelter for small-sized mammals, birds and many insects. A very small change can bring a huge change, like the addition of a new plant can bring an important increase in insect staffing (Sperling *et al*., 2006).

### Diptera

Order Diptera contained 1,000,000 species. These species consist of houseflies, midges, blackflies and mosquitoes (another species gnats that are assembled in 10,000 genera and belongs to 188 families). The word Diptera originated from the Greek word and "di" represented as "two" whereas word "ptera" showed as "wings" so-called true flies (Mayer, 2009). Flies live in the living human environment and may be diurnal or nocturnal insects. Flies transfer pathogens by mechanically and non-mechanically in high amounts as they are very fast to human's food and in the living environment, particularly in warm-season (Goddared, 2007).

### Coleoptera

The members of order Coleoptera mainly found on flowers, leaves, buds and shoots. Coleopterans are pests as well as they control the pest population. For example, dung beetle (Scarabaeidae) used to decrease the population of pestilent flies as well as parasitic worms, which act as pests. Ground beetles (Coccinellidae) decrease the population of aphids by feeding on them. Aphids suck the saps of plants by staying on the shoots, flowers, pods and stems of the plants (Ion *et al*., 2007).

## II. Urbanization

Most of humans live in urban areas and increasing urbanization which affected biodiversity on a large scale. Cities give diverse environments to biodiversity, with several connections between humans and nature. As urbanization increases, the green land decreases and in result of it, biodiversity affected. Insects are key pointers that allow the checking of the influence of urbanization on biodiversity, responding sympathetically to changes in the range and quality of habitat and to change administration practices related to urbanization. Urbanization fundamentally changes land sides, habitat building and ecological functions (Sochat *et al*., 2006; Fateh *et al*., 2005).

## III. Light Trap

Light is the natural manager that helps to make things visible. Artificial lights charm the insects (Land and Nilsson, 2002). The reactions of insects towards light depend upon certain factors like time of contact, color of the light, wavelength combination, direction of light, light intensity and the contrast of light intensity (Coombe, 1981). Artificial light is important feature that helps to find nocturnal insects (Holker *et al*., 2010). Several nocturnal species fascinated towards artificial light, these species included grasshoppers, moths, beetles and stinkbugs (Cowan and Gries, 2009). The yellow-colored light is also used to attract the insects of orders Coleoptera, Diptera and Lepidoptera (Ashfaq *et al*., 2005). Some pests of crops attract to yellow colored light, examples of these insects are planthoppers, leafhoppers, aphids, whiteflies, thrips and leaf miner flies (Esker *et al*., 2004).

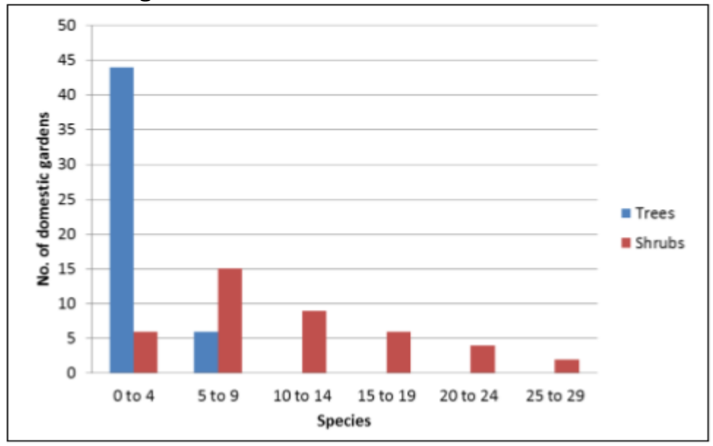
A huge variety of nocturnal insects that lives in the gardens are caught by the predators in the presence of artificial light. The wavelengths of un-polarized light which are emitted by the high-intensity lights can attract insects directly. It is believed that this attraction is the maladaptive significance and inborn tendency of insects to steer by using the light of moon. Many nocturnal lights are present on roadsides. The degree of polarization of artificial light becomes 60% higher than the Brewster angle (Frank *et al*., 1988; Gaston et *al*., 2013; Eisenbeis *et al.*, 2001).

Artificial lights delay with an insect's ability to perceive the moonlight. They appear optimistic and discharge their light in several directions. When insects come close to artificial bulbs, then they start to navigate through artificial light. Light of bulbs discharge in all directions, so the insect could not use the light as a source of contrast angle. The luminous light of bulbs attract the greatest number of insects, the bulbs that attract the highest numbers of insects are halogens globes and cool colored LED's, warm LED bulb (Bowden, 1981). A decrease in insect capturing comes by bright moonlight with light traps. This effect credited for direct competition from artificial light to moonlight (Hosking, 1979; Bishop *et al*., 2000; Lang *et al*., 2006). It is unidentified, whether attraction by light traps are appropriate or not for insect sampling method in urban areas because competitions exist with many non-natural lights.

## IV. Discussion

A total of 160 trees from 25 species as well as 117 species of herbs and shrubs were encountered in 50 households of the sampled area. We encountered an average of 5 tree species per garden, and about 90% of the houses sampled had less than five tree species.

**Fig. 1: Frequency distribution of tree and shrub species across 50 domestic gardens**




The most common trees found in more than 30 percent of the home gardens are *Mangifera indica* (mango), *Polyalthia longifolia* and *Cocos nucifera* (coconut). The most common shrubs found in more than 30 percent of the home gardens are *Rosa* spp., *Bergera koenigii*, *Codiaeum variegatum*, *Jasminum* spp., *Chrysalidocarpus lutescens*, *Hibiscus rosasinensis* and *Ocimum tenuiflorum* (Fig. 1).

Total 2,185 insects from 10 orders were recorded and of those 1,072 insects belonging to eight orders. Coleoptera, Dermaptera, Diptera, Hemiptera, Hymenoptera, Lepidoptera, Neuroptera and Orthoptera were captured using the light traps, while 1,173 insects belonging to nine orders i.e. Blattodea, Coleoptera, Dermaptera, Diptera, Hemiptera, Hymenoptera, Isopoda, Neuroptera and Orthoptera were captured through pitfall traps. Insects belonging to order Lepidoptera were only encountered in light traps, while insects belonging to the orders, Blattodea and Isopoda were encountered solely in pitfall traps (Table 1).

**Table 1: Insects belonging to different orders encountered in pitfall traps across 50 domestic gardens**

| Pitfall Traps | | | |
|---|---|---|---|
| **Order** | **Minimum** | **Maximum** | **No. of individuals** |
| Blattodea | 1 | 3 | 28 |
| Coleoptera | 1 | 21 | 152 |
| Dermaptera | 1 | 9 | 28 |
| Diptera | 2 | 9 | 23 |
| Hemiptera | 1 | 9 | 146 |
| Hymenoptera | 2 | 68 | 659 |
| Isopoda | 1 | 9 | 39 |
| Neuroptera | 2 | 6 | 27 |
| Orthoptera | 1 | 3 | 11 |

Four orders i.e. beetles (Coleoptera), flies (Diptera), bugs (Hemiptera) and ants (Hymenoptera) were widespread and abundant, collectively providing over 87.13% of total captures in pitfall and light traps. Hymenoptera was the most common order encountered in the sampled gardens (n = 50, light trap = 98%, pitfall trap = 100%) followed by Hemiptera (n = 50, light trap = 52%, pitfall trap = 78%) and Coleoptera (n = 50, light trap = 46%, pitfall trap = 64%). The garden with the greatest number of insects was located at the periphery of the city, with 120 insects belonging

| Light Traps | | | |
|---|---|---|---|
| **Order** | **Minimum** | **Maximum** | **No. of individuals** |
| Coleoptera | 1 | 10 | 69 |
| Dermaptera | 1 | 4 | 33 |
| Diptera | 1 | 9 | 89 |
| Hemiptera | 1 | 11 | 103 |
| Homoptera | 4 | 11 | 36 |
| Hymenoptera | 3 | 65 | 663 |
| Lepidoptera | 1 | 7 | 46 |
| Neuroptera | 1 | 4 | 13 |

to five orders, while the garden with the least insect order richness had a recorded 12 individuals of five orders, closer to the city center (Table 2) (Jaganmohan *et al.*, 2013).

**Table 2: Insects belonging to different orders encountered in light traps across 50 domestic gardens**

Throughout the study, the nocturnal fauna was recorded. It included the nocturnal visitors of *A. triphylla* flowers were predominantly settling moths (mainly Noctuidae, Crambidae and Pyralidae), and only one visit by Geometridae was recorded. These moths visited *A. triphylla* flowers most frequently 1 to 2 hours after sunset and their foraging behavior varied among taxa. Other nocturnal visitors were hoverflies, non-syrphid Diptera, hawkmoths and earwigs. All the hawkmoths observed visiting during the night were day-flying species (*Macroglossum* spp. *and Neogurelca* spp.), which visited *A. triphylla* flowers during early dusk or early dawn. They continued to flap their wings while feeding and frequently flew between flowers or plants. Pyralid and crambid moths crawled into corolla tubes without flapping their wings and probed nectar. Their foraging movements between flowers or plants were less frequent than those of noctuid moths. Visits from earwigs were omitted from analyses (Funamotol and Ohashi, 2017).

Gang and Chun-Sen (2012) resulted that 102 most common insect species were caught by the traps and they were identified as pests and beneficial insects. The pests were mainly Lepidoptera (3453 individuals belong to 55 species), Coleoptera (11752 individuals belong to 22 species) and the beneficial principally predatory insects (1503 individuals belong to 6 species). Thus, in the light trap catches, coleopteran and lepidopteran pests were the most abundant pests, predatory insects and prey the most abundant natural enemies (Fig. 2).

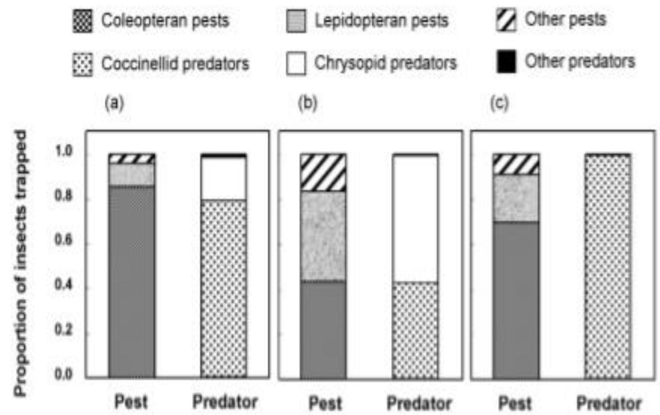



**Fig. 2: The proportions of coleopteran, lepidopteran and other pests and Coccinellid, Chrysopid and other predators in the total catches of pests and predators, respectively, caught by light traps at Changping (a) Haidian (b) Zijiao (c) Data consists of the total numbers caught on 108 nights over the period 2003 to 2005.**

The 10 most abundant coleopteran pests and 12 most abundant lepidopteran pests in the light trap catches were selected. Similarly, five predatory species i.e. two Coccinellids and three Chrysopids were the most abundant insects in the catches. Hourly percentages of all the species of Coleoptera trapped was greatest in the first two hours, ranging between 50-80%, and then the percentage trapped each hour decreased dramatically after 10 pm. In contrast, hourly percentages of most of the species of Lepidoptera trapped were < 20% before 02:00 and then increased to 20-40% in the last two hours (02:00–04:00). For *Macdunnoughia crassisigna* and *Hyphantria cunea*, the peaks in the percentages trapped occurred between 01:00 and 03:00. Hourly percentages of predatory insects trapped remained relatively constant throughout the night (Fig. 3).

**Fig. 3.3: The relationships between the cumulative % of Coleoptera pests (a) Lepidoptera pests (b) predatory insects (c) trapped and time in hours after 8:00 pm. Lines and circles are the regression curves and hourly percentages, respectively.**

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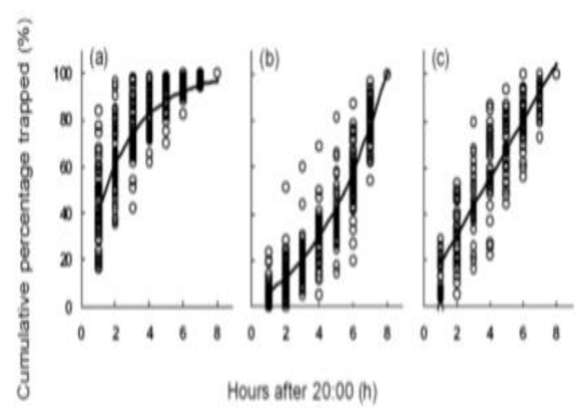


**are the regression curves and hourly percentages, respectively.**

Okamoto *et al.* (2008) provided a list of flower-visiting insects. Overall, 75% of the visitors were nocturnal moths and the remaining visitors were mainly diurnal bees (11%), beetles (3%), butterflies (5%) and flies (8%). The moths visited the flowers most frequently from 6:00 to 7:00 pm. The moths landed on flowers and extended their proboscises into the corolla to probe nectar. Settling moths collected on Diplomorpha flowers belonged to the following six families: Pyralidae (55%), Geometridae (28%), Arctiidae (2%), Nolidae (2%) and Noctuidae (13%). Hawkmoths were not observed visiting Diplomorpha flowers. Nocturnal settling moths had proboscises that ranged between 3.9 and 17.3 mm; thus, 11% of the moths were not able to probe nectar from Diplomorpha flowers (Table 3).

**Table 3: Comparison of floral morphology, nocturnal frequencies of flower visitors among five species**

| Plant species | Flower color | Nectary depth(mm) | Nocturnal visit frequency |
|---|---|---|---|
| *D. ganpi* | Cream white | 7-8 | 7.8 |
| *D. phymatoglossa* | Whitish yellow | 4-5 | 1.1 |
| *D. sikokiana* | Whitish yellow | 7.5-8.5 | 1.3 |
| *D. trichotoma* | Greenish-yellow | 6-7 | 1.3 |
| *D. yakushimensis* | Whitish yellow | 4-5 | 3.2 |

Jonason *et al.* (2014) resulted that total 49472 individuals were caught which belonged to 372 species. Most species belonged to two families: Noctuidae (46%) and Geometridae (33%). The two most abundant species were the two Noctuids *Xestia nigrum* and *Hoplodrina octogenarian*, comprising 14% and 10% of all individuals caught, respectively. Most species were rare; singletons of about 20% of all species, and five or fewer individuals of about 40% of the species were recorded. Species richness and abundance per night was positively correlated with temperature and negatively correlated with air humidity.

There were also significant differences in catches between the two lamps used; the trap with the 250 W mercury lamp caught 29953 individuals representing 334 species, while the trap with the 40 W ultra-violet fluorescent tube caught 19519 individuals representing 299 species. The uniform estimate of temperature effects was an order of magnitude larger than the regular estimate of lamp type effects, suggesting that temperature was the most important factor for trapping moths. Species richness and abundance were not significantly influenced by rain or wind speed. The number of species captured per night increased dramatically in mid-May and remained high (40 species) throughout August. Catches of about 25% of species peaked during spring (March-May), 65% during summer (June-August), and about 10% during autumn (September-October). Moth abundance displayed a similar pattern to species richness but showed a clear peak at the beginning of April. The similarity indices showed that there were large changes in species composition over time.

More species were captured when sampling on warm nights than when sampling, during the same number of nights, with no specific temperature restrictions. At low sample sizes (10 nights), slightly more species were captured when sampling was restricted to the warmest summer nights, but at larger sample sizes (10 nights), slightly more species were captured when sampling during the warmest nights of each month. During warmest months, after 30 nights 60% species were captured when using the trap with the 250 W mercury lamp, and 55% when using the trap with the 40 W ultra-violet fluorescent tube.

## V. Conclusion

The nocturnal insects totally depend upon gardens and color signals. Total species richness and abundance of nocturnal insects altered by certain factors like temperature, humidity and lamp type. Five orders i.e. Coleoptera, Diptera, Hemiptera, Hymenoptera and Lepidoptera were widespread and abundant in different gardens and play a major role in the garden's sustainability.

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