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RESEARCH ARTICLE

LIGHT TRAP AND INSECT SAMPLING: AN OVERVIEW

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ABSTRACT

Terrestrial insects are most diverse groups of animals and contribute to the biodiversity to a large extent. Light trap sampling is commonly used in insect biodiversity studies. A wide variety of light traps with different light designs are being used. Numerous light sources have been used to access the photo response of the different insect species since last forty years. However, not all the light sources proved efficient to attract and collect all the nocturnal insect species insects in a particular habitat. The success of light traps is affected by a wide variety of factors. Environmental conditions, trap design, height of the light source, attraction radius of a light source, surrounding anthopogenic lights, wave length, intensity of light source, timing and duration of light trap, all affect the success of light traps. Therefore, we are presenting an exclusive review of light trap in a single window system.

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INTRODUCTION

Proper documentation of insects is an important component for the study of biodiversity and population dynamics. Most of the insect species are robust; therefore proper sampling needs adequate sampling techniques for the collection of particular group of insects (Russo *et al.*, 2011). Ground dwelling insects particularly formicidae (Ants), Certain Coleoptera (Beetles) etc are best sampled through pitfall trapping. Low flying diurnal insects are collected through Malaise trap and the robust ones by Sweep net method (Malaise, 1937; Marinoni and Dutra, 1997; Mason and Bordera, 2008; Aguiar and Santos, 2010). However, there are thousands of insect species which are nocturnal and cannot be collected by the conventional methods. These insect species are best sampled though light trapping (Szentkiralyi, 2002). Here we are presenting an overview of the light trap sampling and the different sources of light which are being used over the years to contribute to the vast diversity of insects.

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Light trap

Majority of insects are nocturnal, Automatic, self-operating light traps may be useful to assess the quantitative abundance of these group of insect species (Szentkiralyi, 2002). Certain insect species use lunar light for navigation. They keep the angle that the light rays subtend to their eyes constant and fly in a more or less straight line. In the bargain, if a nearer and brighter light is confronted, they take a spiral path and hits into the light source (McGavin, 2007). Suitable sampling technique is important because different sampling methods have different propensity to assess the different components of the fauna and these components may differ in number of species (Basset *et al.*, 1997). Light trapping is most common and regular sampling technique (Szentkiralyi, 2002). In recent times, the light sources, which produce large amounts of UV radiations has revolutionized the light trap sampling (McGavin, 2007). Nocturnal arthropods particularly insects are attracted by artificial light sources (Nag and Nath 1991; Axmacher and Fiedler 2004). Light traps have been widely used for collection of nocturnal insects (Ricklefs 1975; Morton *et al.* 1981; Thomas 1996; Holyoak *et al.* 1997; Axmacher *et al.*2004). Light traps are expensive, but are very efficient for collection of insects (Basset *et al.* 1997; Liu *et al.*, 2007). Different light sources like mercury vapour lamps, gas lamps and fluorescent UV light tubes are been used (Brehm and Axmacher, 2006) for sampling purposes. Insect are lured by light and fall the victim of getting trapped into the collecting chamber. UV light traps are relatively inexpensive, hence mostly used. Mercury as well as black light collects more insects than incandescent light. Light traps are efficient to collect the insects like moths, beetles, bugs, some flies and other active insects (Lindquist *et al*., 1983; Borror, 1981). Certain species of nocturnal insects can be caught through light trapping at a particular point of times during night (Kitching and Cadiou, 2000). Light trap data provide valuable information about the distribution, abundance and the seasonal flight periods of insects (Walkden and Whelan, 1942). With a minimum effort, light trapping yields large number of insect specimens (Holloway et al. 2001, Fiedler and Schulze 2004) and is particularly true for automatic light traps (Southwood and Henderson, 2000). Because, these traps do not require observer to examine all the time.

Light trap design and insect sampling

Various kinds of light traps have been developed from time to time. Many workers have used different valuable designs of light traps (Southwood, 1978; Muirhead-Thomson, 1991; Fry and Waring, 1996; Davies and Stork, 1996). During the last 50 years, numerous designs of light traps has been exploited for trapping nocturnal insects (McGavin, 2007). An extensive study was conducted in New York on different kinds of insects caught in light lantern traps (Slingerland, 1902). Vermorel (1902) reported the use of trap lanterns using acetylene in France for insect sampling. As the new light sources developed, attractant equipments begin to change as well. Gasoline arc lanterns fixed in 5 inch deep with galvanized pans to collect the certain insect species were used in Wisconsin (Sanders and Fracker, 1916). For the collection of cotton pests, A specialized light trap was devised in Egypt. Wide visibility of light emitted was the main feature of the trap and carbon tetrachloride as killing agent (Williams, 1923). Light traps catch crepuscular and nocturnal insects using a luminous source having different wavelengths (Schauff, 2012). Certain insect groups like Diptera are attracted in large numbers by incandescent traps while Lepidoptera are attracted strongly by ultra-violet light (Southwood 1978). Similarly, mercury vapour light traps catch other insect fauna efficiently (Marshall *et al*., 1994). Insects like bugs, beetles and moths, are attracted to almost any kind of light source in tropics (McGavin, 2007).

Electric insect traps

Light traps utilizing electric lamps as the attractants can be classified into three groups viz. Electric grid, Suction or fan type and Mechanical or gravity trap. The first and second type require 110 V electric supply while the third type operated directly at 110 V. However very few are powered by dry cells or storage batteries. Light trap design operating on dry cell was reported by Nelson and Chamberlain (1955). New Jersey type light trap operating on 6 V battery was described by Sudia and Chamberlain (1962) and a survey type electric insect sampling trap was developed by Hollingsworth and Briggs (1960). Light trap with a self-contained inverter, installed with a timer for controlling periods of light were developed by Wagner et al. (1969). Different types of general insect survey light traps viz., CDC' miniature light trap: cigarette beetle trap; New Jersey mosquito trap; Pink bollworm trap; European chafer trap and Asiatic garden beetle trap have been described by Frost (1952) and Hollingsworth et al. (1963). High voltage and electrocuting grid, conjugated with insect traps is actually a shock and fire hazard (Dalziel, 1951). Therefore, use of this trap is for destruction of insect populations particularly to eradicate the insects around residences. Akins trap was developed for the control of certain pests. This trap consists of an inverted funnel shaped reflector with a light socket, a lamp, iron sleeves, muslin bag and an electric fan with a motor to draw the insects into the trap (Essig, 1930). An innovative suction light trap consisting of flange, barrel and a cone with a lamp has been reported by Reed et al. (1935) for the collection of insects particularly coleoptera. Another ramification of the trap was to add a pint jar to the bottom of the funnel, to make it more refined (Hallock, 1936). Gryse (1933) reported a new light trap equipped with four trays, efficient in separating the insect collection according to size. Dirks (1937) used light traps to collect the life history data of certain specific species of insects. The traps operated with incandescent lamps viz., 200 W, 500 W, 1000 W. Inside frosted types and a sun lamp as attractant, a pan of water with kerosene film were used for sampling. Hallock (1936) reported lights of shorter wavelengths near violet end of the spectrum are most valuable to lure the beetle. Insect species differ in the attractiveness and depends upon the specific wave length of light. Laboratory tests show European corn borer has maximum attractiveness near ultraviolet region of the spectrum (Taylor and Deay, 1950). Similarly, species like *Pectinophora gossypiella* show a tendency towards UV light (Glick and Hollingsworth, 1954).
Diametrically opposed theory of light response phenomenon is shown by nocturnal insects. Nocturnal insects are repelled by light, but if they fly quickly, will approach close enough to light to be dazzled by it and in the process deflect into it (Robinson and Robinson, 1950; Robinson, 1952).

Figure A personal funnel shaped mercury light trap

Types of light traps

There are two types of insect light traps viz., box type and funnel type. An outer wall containing a light source consists of two panes of glass sloping to a narrow horizontal aperture in case of box type traps. As the insect enters into chamber, there is little opportunity to escape. In case of funnel shaped trap, a light source is suspended over a funnel which tappers into a chamber beneath it. As the insect enters into the chamber through funnel, it can not escape (Hardwick, 1968). Funnel shaped trap was initially devised for the collection of moths but its use is common for insect collection now a days. Initially, it consisted of a galvanized iron funnel of 30 inches long, one end with a 12-inch and rear end with 3-inch diameter. Perpendicular and beneath to the main funnel is placed a rectangular funnel which in turn receives a jar with killing agent. Insects attracted to the lamp are collected into the jar (Merkl and Pfrimmer, 1955). These traps became important tools to the entomologist community to assess the seasonal abundance and the time of appearance of important insect pest species (Stanley and Dominick, 1958; Tashiro and Tuttle; Oatman, 1957; Smith, 1962). Low pressure mercury arc discharge lamps emit light predominantly at a wave length of 253.7 nm and fluorescent black light lamps converts the 253.7 nm to longer ultraviolet wavelengths due to the use of phosphor. However, black-light-blue lamps operate with red-purple bulbs to absorb the visible radiations while as fluorescent sunlamp peaks between 310 – 340 nm. A combination of blue, violet and near UV radiant energy is generated by Argon glow lamp. Incandescent lamps with a trademark of Mazda operate with filaments of tungsten and important types are Mazda B (vacuum lamp) and Mazda C (gas-filled lamp) (Hienton, 1974). Williams (1948) developed Rothamsted type light trap, which is very efficient for insect sampling and is still in operation. Jermy's light trap consists of a circular roof fixed to a column two meters above the ground and the light source hangs beneath lower side of the roof. Followed along is a funnel tapering into killing jar. Thus, the insects enter through funnel into the jar (Jermy, 1998). Robinsons MV moth trap, uses vapour discharge bulb and requires connection with a generator or mains supply. Thus, this trap is not useful where vehicle couldn't be driven. There is certain variation of the Robinsons light trap like Heath trap, which can run from a 12v motor cycle or car battery. Therefore, it can be used in remote areas (McGavin, 2007).

Insect response and wave length

Low pressure 15 watt mercury arc discharge lamp (GE germicidal lamp-GIST8) and 6 watt GE black light lamps (F6TS-BL) emits radiant power predominantly at 253.7 nm (GE refers to General electric company). Black light-blue lamps (F15TS-BLB) of GE 15 watt strength absorb visible radiations (Hienton, 1974). 40 watt and 10 watt GE fluorescent sunlamp (erythermal F20TI2) has a range between 250 to 460nm but peaks at 340 and 310 nm respectively. However, G-I low pressure mercury arch lamp radiates visible and UV radiations shorter than 600 nm and G-5 mercury arch lamp radiates UV energy between 280 to 400 nm approximately (Hienton, 1974). Phototaxis of insects is affected by physiological as well as physical factors (Hartsock, 1961; Deay and Hartsock, 1961; Kovrov and Monchadsky, 1963). Lubbock was the first to observe that ants are not attractive to ultra-red rays. Glick and Hollingsworth (1954) reported the attraction of ultraviolet and mercury light to the pink bollworm moth. Certain insects extend the range of responses into the UV region or more precisely below 300 nm (Goldsmith, 1961). However, many insects show peak response in the UV region at about 365 nm (Weiss 1941; Hollingsworth 1961). Other insects show a peak response in the range between 490 to 520 nm (Goldsmith 1961; Hollingsworth, 1964; Stermer, 1959; Weiss, 1944).

Attraction radii

Attraction radii for most of the lights is supposed to be in between 3- 250 meters which inturn depends upon the study method and species type (Muirhead- Thompson 1991, Bowden 1982). However, researchers argue that attraction radii are smaller than 30 meters for normal light sources (Butler and Kondo, 1991, Muirhead-Thompson, 1991).

Factors affecting light trap catch

Weather is an important factor, which decides the light trap catch. Light trap catch is influenced by type of vegetation, lunar light and weather. Though, the effect of vegetation around the sampling site might be overestimated (Schulze and Fiedler, 2003), impact of weather (rain, fog, temperature, fog) and lunar light have been discussed in detail (Muirhead-Thompson, 1991; Holloway et al., 2001; Yela and Holyoak, 1997; McGeachie, 1989; Brehm , 2002). Wallace (1869) has mentioned that warm, humid and moonless nights produce a rich sample of insects in general.

Limitations and difficulties with Light traps

The problem with the light trap data is its difficulty to be sure over what area the trap is effective. In dense habitats like forests, the range of illumination may be very small. Therefore, best part of light trap data is to show the presence and relative abundance of particular species but for quantitative analysis, it is tricky (McGavin, 2007). However, Wolda (1992) and Simon and Linsenmair (2001) mentioned that they measure activity rather than relative abundance. They sample communities selectively rather than randomly and different species react differently to light (Bowden 1982, Butler et al.1999). Light traps preserve specimens efficiently. However, the main disadvantage of light traps is their limitation to nocturnal species and hence direct comparisons of quantitative data is difficult (Basset, 1988).

One of the problems with light traps is that it is not sure what will be attracted to them and what will be repelled. It depends up on the conglomerate action of behavoural, physiological and environmental factors. Many insect species do not fly to the lights, though there may be large numbers nearby (McGavin, 2007). Light trap catch is affected by many variables like trap size, design, height, bulb type and surroundings and varies between species (Baker and Sadovy 1978; Bowden 1982). Timing of trap operation, illumination by moon light and antropogenic light sources also decides the insect catch (Morton *et al*. 1981; Bowden 1982; Nag and Nath 1991; Nowinszky 2004). Vapour discharge lamps for street lighting has reduced insect populations particularly the moths and even predators cash on these insects during the night hours. For example, weaver ants (*Oecophylla smaragdina*) queuing up along fluorescent light to catch insects (McGavin, 2007).

Conclusion

There are many sampling techniques of insect collection, active as well as passive. However, nocturnal insects are collected exclusively through light trap and play an important role in the field sampling of nocturnal insect populations. Insect capture rates of different light sources and designs are highly variable and are affected by a wide range of factors. Therefore, while installing a light trap, environmental conditions, trap design, height of the light source and attraction radii of the light source must be taken into the consideration. The light trap success depends up on the intensity and wave length of the light source. Because most insects are attractive to a particular range of wave lengths. Also high voltage light source can burn the important identification marks or the body parts of the insect. Therefore a light source with adequate voltage should be used for successful sampling.

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