Plain talk for entomologist about ultraviolet light

by

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In the past 40 years or so, entomologists have used ultraviolet lamps in ever increasing numbers to attract, collect, and sample insects of all types that have flight capability. This report discusses some basic issues concerning the various features of fluorescent and high intensity discharge lamps, both of which emit blacklight. Safety considerations, as well as which currently available lamps are better suited for attracting insects are included among the topics covered. The relationship of various lamps and light trap design is touched upon. Views expressed here are based upon valid conclusions from published research as well as my personal findings from designing, fabricating and operating light traps year-round for 22 consecutive years in Louisiana. During this period ±300 light traps have been fabricated to many sizes and designs, and countless lamps have been experimented with by the author.

There is a plethora of published investigations in literature concerning these topics. Those wishing to learn more about the development of various insect light traps will find 1,000 or more published articles going back more than 100 years. More notable and relevant are those by Frost, Glick, Pfrimmer, and others, published nearly 40 years ago. Besides reports on visible and ultraviolet light, dozens of published investigations are available from around the world involving attraction of insects to many other parts of the electromagnetic spectrum, including radio frequencies, infrared radiation, X-rays, and gamma rays.

Definitions and abbreviations are listed here for some of the terms used in this discussion.

angstrom - one ten-billionth of a meter
blacklight - lamps which produce primarily near-ultraviolet radiant energy in the range of 320 to 400 nm.
bulb - specifically the glass envelope part enclosing a light source, or more commonly the term used to described the entire structure, glass envelope and light source.
lamp - any device for producing light or heat.
mercury vapor - (Hg) a lamp in which the outer envelope is made of borosilicate glass and contains nitrogen, while the quartz arc tube contains mercury and argon.
nanometer - (nm) one billionth of a meter.
ultraviolet - (uv) wavelengths less than visible light and longer than those of X-rays, between 10 and 380 nm.

UV radiation generally encompasses 10 to 380 nm on the electromagnetic spectrum. The near-uv or blacklight band is 320-400 nm, the erythemal band is 280-320 nm, the bactericidal or germicidal band is 220-300 nm, and the ozone producing band is 180-220 nm. The erythemal band is responsible for sunburn, suntan, and producing vitamin D in the human body.

The uv radiation in a high pressure mercury arc is twice that of its visual component. Eye protection is essential for all who are exposed to direct or reflected uv radiation. This is especially so if the radiation is intense or one is exposed to it for extended periods of time. Failure to protect eyes can result in temporary painful inflammation of the conjunctiva, cornea, and iris, also photophobia, blepharospasm, and ciliary neuralgia. Blistering of the cornea and conjunctivitis are common maladies among light trappers who use high intensity mercury vapor lamps. If the outer envelope is broken or punctured, serious skin burns and eye irritations are even more likely.

Photosensitivity, an abnormal skin reaction, occurs from both sunlight and artificial light. Adverse effects can occur in wavelengths of light between 250 and 800 nm. Continued exposure to
Lamps emitting wavelengths in the 290-320 nm area (peaking at about 297 nm) are responsible for acute sunburn reactions. In this range, the shorter wavelengths cause quick sunburn, while the longer wavelengths penetrate deeper and cause tanning. Other photosensitizers (drugs, chemicals, and diseases) in combination with particular wavelengths can result in phototoxic or photoallergic reactions.

Sunlamps were introduced to the public in 1929. They were used for tanning at home. Many types of sunlamps were developed over the years. One type, the RS sunlamp (a self-ballasted mercury vapor lamp) has been more often used by some insect collectors for the past 40 years. It incorporates a 175 watt tungsten filament resistance ballast and a 100 watt mercury discharge element inside a UV transmitting reflector type envelope. These lamps nearly disappeared in the early to mid 80's due to injury lawsuits. People would fall asleep while tanning under the lamps, causing skin and eye injuries. Laws were passed that they be made to operate only in conjunction with a timing device to limit exposure time. Consequently, several manufacturers opted to discontinue the lamp altogether. One manufacturer continued to produce the lamp, but with a mogul base. Thus preventing its operation from a medium socket (normal household socket). Along with the newly designed sunlamp, the consumer was required to purchase a fixture containing a timing device with a mogul socket. For those familiar with electrical parts, this whole grand idea could be thwarted by purchasing an adapter for several dollars. The adapter allows a mogul base lamp to be screwed into a medium socket.

It seems the last manufacturer is no longer producing this lamp. The RS sunlamp and its ability to attract insects was reported by Glick and Hollingsworth in 1955. Some collectors have routinely used it as an easy to use source of UV light and as an adjunct to fluorescent blacklight. The sunlamp provided a spectral distribution nearly identical to fluorescent blacklights, but from a more powerful source. Before the change to a mogul base, it required no special external device to operate. The RS sunlamp gained popularity because it was powerful and easy to use. In reality, it was a less than ideal choice for attracting insects. It was a spot type lamp. Several to many were needed to gain all around coverage of an area. They were expensive and were subject to breakage due to thermal shock (rainwater striking the glass). This was especially so when the lamp had a medium base. After the change to a mogul base, the lamp operated cooler and less thermal shock breakage occurred. Using several lamps to obtain wider area coverage consumed a lot of power. Also, 175 watts of each lamp was consumed by the internal ballast and was not generating UV light. A much superior alternative for a powerful blacklight source is discussed next.

Mercury Lamps - Most mercury lamps produce both visible and black light. They are the most powerful source of blacklight commonly used. They are compact and allow 360° coverage of large areas. They may be operated in any position. They do require auxiliary ballast and all have mogul bases. The auxiliary ballast can be a negative feature e.g. for a 1000 watt mercury lamp, the ballast alone may weigh 35 pounds. Lamp designations are explained in the following example of a 1000 watt clear mercury vapor lamp. Model no. H36GV-1000. H indicates mercury lamp, 36 indicates ballast type, GV indicates characteristics of the lamp, 1000 indicates lamp wattage. Additional letters after wattage would indicate type of phosphor or special glass coloring, no suffix means clear. Clear lamps are considered blacklights; frosted, white or other colored mercury lamps are not. The rated average life of a 400 watt clear MV lamp is e.g. 24,000+ hours. In this case, 67% of these lamps continue to operate after 24,000 hours of operation. The light output of a new lamp declines with burning hours, and may be reduced to between 35 and 70% of its original light output by the time it reaches 24,000 hours of operation. Wattage losses in ballast usually run 5-15% of lamp wattage depending on lamp and ballast type.
Radiant Power (Microwatts Per 10 Nanometers Per Lumen)

Wavelength (Nanometers)

RADIANT POWER (Microwatts Per 10 Nanometers Per Lumen)

Ir-o, 0 350 450 500 550 600 650 700 75

WAVELENGTH (Nanometers)

CLEAR MERCURY

100 watt H3811-100
115 watt H3982-115
250 watt H3768-250
400 watt H3830-400
1000 watt H3690-1000

Mercury lamps are usually effective on public-subsidied in shape depending on manufacture.
Fluorescent lamps - These lamps are the most efficient source of blacklight and operate cool. They deliver full uv output immediately after being turned on. There are two kinds of blacklight fluorescent lamps (BL and BLB). Blacklight lamps differ from standard white fluorescent lamps only in the composition of their energy radiating phosphor. Fluorescent blacklight energy peaks about 350 nm in the near uv region. (see graph) The BLB lamps are the same as the BL except the tubes of the BLB are made of a special filter glass. This filter glass absorbs nearly all the visible light, but some of the near uv energy is also absorbed by this filter. Compared to the BLB lamp, a BL lamp emits 25% more relative blacklight energy. The output of blacklight fluorescent lamps depreciate over time more rapidly than standard fluorescent lamps. Fifteen watt lamps are the most common size used by insect collectors, but wattages from 4 to 85 are available. Shapes are standard straight tubular, U-shaped, and circular.

Many light trap designs have evolved over the years. The most successful are those involving a light over a funnel or other collecting device. Not surprisingly, research has shown that insects approaching a lamp will more often dive below or at the base of the lamp, and not necessarily at the lamp itself. Also certain species of insects intersect the glowing area of the lamp at certain distances away from the lamp itself, not directly at the lamp itself. The addition of baffles also increases the quantities of insects collected. Other conclusions concerning light traps are: black baffles (non-reflective) increase yield, a larger funnel increases yield, baffle size is dependent on types of insects sought. Baffle size is dependent also on funnel size, both should compliment each other.

From literature, general conclusions about light sources used for attracting insects are:
more blue = more insects,
more red or yellow = less insects,
brighter source = more insects,
bare lamps attract more insects than lamps in reflectors or weather protecting devices.

Those wishing greater yields in light trapping should consider using traps with funnels and baffles as large as practical along with lamps of highest wattage. Ideally there should be some limiting relationship between size of the trap and the size of the lamp or amount of light it projects. There surely is a saturation point at which more light or trap size won't increase yield significantly to warrant the increase cost of equipment and it's operation. Such conclusions are obviously dependent on numerous factors. All of these attempts to improve yield are somewhat negated by attempting to make light traps more portable. There are ways to lessen some of these negative factors in alternate designs.