Light Pollution Decimates Insects in the Environment

This page covers:

Light pollution's impact on other species in the environment are found here.

> Butterflies... not quite birds, as they were not quite flowers,
> mysterious and fascinating as are all indeterminate creatures.
>
> - Elizabeth Goudge

Insects

Two thirds of the animal protein consumed on our planet comes from insects. They lie at the bottom of the global predator-prey food pyramid. Humans are among those that occupy the peak. If the foundation becomes eroded, then the entire pyramid becomes compromised and our food sources are sorely disrupted.

Remember, conservation is not about "hugging trees". Conservation is an intellectually aware and a selfish set of actions and beliefs that strive to perserve animals, plants and the environment, becuase ultimately, these actions will perserve us humans. And of course, what a better usage of our time than what so many of our other activities tend to do.

The following is a essay that summarizes the thoughts and perceptions of Dr. Philip DeVries on the effects of light pollution in the tropical forests that he has experienced. While he wrote it back in 2003, I am very grateful for Phil's current and generous contribution to the page, which is reproduced in its entirety without any editting on my part. Thank you, Phil.

Essay: The tropical light within

P. J. DeVries © 2003

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Source: *Ecological Consequences of Artificial Night Lighting*. Catherine Rich & Travis Longcore (eds). 2006. Island Press. Covelo, CA. Pages 281-304.

Long ago I discovered my inability to use a library or a dictionary efficiently. I am too easily attracted by words and images. Like a moth to a lamp, they deflect me toward paths and directions already taken or suggested by others – particularly when the words and images concern tropical forests. I recall the first books on the topic I ever held in my hands. They filled my mind with strong imagery of trees, animals, insects, people, and landscapes bathed in a special light. I kept seeking more books until a time when there was a change; a desire burned within to discover tropical forest in person.

As a tropical biologist I have been privileged with a wealth of opportunities to study insects, particularly butterflies, in tropical forests. I've shared field experiences with exceptional people from all walks of life who have left me with their own distinct perceptions about nature and our place in it. I've covered a lot of ground: North, Central and South America, Africa and Southeast Asia, Europe and various islands. I've aged in the field, and the body doesn't spring back as quickly as it once did. Nevertheless, through time my desire to continue this wandering lifestyle has not diminished. Rather, the quest to experience more burns the brighter.

There is an utterly magical time that occurs at tropical dusk. It is when the calls of birds wheeling overhead recede into the distance, and the constant pulse of insect and frog calls fills the air. The inflection point where both sounds are equal in volume coincides with a time when the failing light is ethereal. This heralds the other half of biodiversity, the nocturnal. Within the forest the phosphorescent light of Pyrhophorus beetles leaves green trails in their wake to tempt would be mates to follow. The eerie glow of bioluminescent fungi astonishes, but vanishes instantly in the light of a headlamp. The pale moonlight gives reflected glimpse of bats trolling the surface of oxbow lakes. Overhead one can gaze into black velvet sky to see stars, and comets and the cosmos beyond. This is the stuff dreams are made of.

Other forms of light are less benign to the magic of the forest. The first lights that send their electrical call in wild places draw myriads of insects. A riot of color, form and diversity that is impossible to imagine in advance. But the insects attracted to the electrical beacons will dwindle over time. Every week there will be fewer and fewer. This is because a great many die at dawn. Birds, toads and mammals quickly learn that there is a ready meal at the lights every morning, and that there is nowhere for the transfixed nocturnal denizens to hide. Ants too are regulars at the lights. With organized effectiveness they incessantly carry away the disoriented, the wounded and the dead. There are further consequences of artificial light as well.

Even the most urbanized person cannot fail to pause at the sight of butterflies. Butterflies are insects that require light of the sun to fly, to reproduce, and to flourish. Daylight is their realm. Nonetheless, a major part of their life cycle, the caterpillar, is a creature often active only at night. To find many caterpillars one must be armed with a flashlight and use the cover of night. The introduction of artificial lights in natural areas has a generous impact on the diversity, distribution and the abundance of butterflies. With electric lights come the roads. With roads come vehicles, people, habitat destruction and more lights. This is quickly attended by a reduction in the species of both adult butterflies and the food plants their caterpillars depend on for survival. The area becomes the realm of common weeds, and this reduces butterfly diversity even more. Fewer plant species equates with fewer butterfly species. This is not illusion or fancy, but common sense that even a child can grasp and measure its truth.

I never thought that so many places dreamed of in my youth could be marked so deeply by the human hand. Crucial details embodied in the concept of forest held by our predecessors are lost by each passing human generation. I understand that during my grandparent's lifetime large carnivores, herds of elephants, and vast expanses of tropical wilderness were common. My experience has been less rich. Many times I've tried to imagine the tropical forests experienced by naturalists a century ago and concluded that they would be shocked at the current scale of decimation, and the intruding pervasiveness of electrical light. In their eyes, our concept of forest would lack depth and vitality. Where is the tropical wilderness? When its absence is finally recognized will we try to reconstruct it like historians who earnestly, but vainly attempt to recreate the vital spark of a culture that has passed from living memory? How will we account for and connect all the parts? That is to say, once the concept of forest with all its components is lost, it can never be fully regained. Merely reconstructed from partial memories that are not our own.

My travels have convinced me that we are among the last generation who will be able to experience tropical forests, think about them, and to be illuminated by them. Humanity has developed with wilderness, and the cover of night. A nocturnal world without escape from the glare of electrical lights is disturbing. The concept of future generations not being able to discover the elegant beauty of a dark, starry night accompanied by the sound of nature is profound tragedy.

This next paper by Prof. Eisenbeis summarizes the altered behaviors of insects by artifical lights at night.

Artificial night lighting and insects: Attraction of insects to streetlamps in a rural setting in Germany.

Source: *Ecological Consequences of Artificial Night Lighting*. Catherine Rich & Travis Longcore (eds). 2006. Island Press. Pages 281-304.

Gerhard Eisenbeis

Department of Biology, Institute of Zoology, Mainz University, Germany.

This paper, translated from its original German, gathers and summarizes researchers' work of fifty-two other papers to help readers see the whole picture of the effect that lighting has on the insect populations in Germany. Not only do insects make up a substantial part of the base of "predator/prey food pyramids", but they are also important to food webs in that they are pollinators for so many plants and so help create food for other animals, for example night-blooming flowers usually depend on moths (or bats) for pollination. The author, Eisenbeis, reviewed the behavior of insects around lights and lights effects on diversity. The papers were able to examine this particular aspect by intelligently using streetlights as the attractant for insect traps and compare the catches with other means. The investigations also looked at the differences between high pressure mercury vapor and sodium vapor lamps, the quantities of insects caught according to insect order, locations of the lamps, temperature conditions and even the lunar phase.

Insect Behavior Toward Lights

The first thing noted was the behavior of the insects toward lights, described in three ways. The first effect is the "near" effect on individual insects, called the "**fixated or capture effect**", which many have noticed regarding insects and lights, creating the cliché. *What most have not noticed is the fact that some insects will fly towards and actually stop some distance before a light, stuck there as if dazzled by the light.* To them, it must be an incomprehensible sight, something well beyond the natural instinct they have encoded in their DNA. Being so "captured" by the light means that then they are then unable to perform their basic functions for life, such as to reproduce. Thus they are removed from gene pool and the species suffers, because some human just can't be bothered to turn off the light. Others insects fly directly into the light, only to get killed by the hot glass surface. Still others try to naturally fly at angles to the light, assuming it is the distant moon, only to enter into a ever tighter spiral around the light and hence become caught by the light. Such insects either become easy prey for other animals or eventually just exhaust themselves, falling dead to the ground.

A time-lapse photography video of insects captured by streetlights called flight patterns from Charlie McCarthy on Vimeo.

The next two effects are broader in scale and their "far" potent effects varies according to background conditions, such the lunar phase or from localized sky glow. They include the "**crash barrier effect**", where a string of lights, such as those along a road that crosses an insect flight path, becomes a actual fence to those insects, prohibiting their crossing. This effect stops the insects movement across the land. The final effect is the "**vacuum cleaner effect**", where the insects are drawn out of their environment to their deaths by a light making the landscape evacuated of life. A brighter lunar phase reduces the contrast of the lights and hence their effect. The lights' strength variations depend on the height of the lights, background sky glow from light pollution sources, and range from 400-600m for dark sky conditions or 50m for full moon conditions, though there is some discussion on how to measure the effect.

Documentation of Insect Declines due to Light Pollution

Eisenbeis noted the declines of insects catches from different decades as reported in three papers. This table helps to show the declines he saw across the decades:

Authors	Year	Publishing Info.	Count of Insects Caught	Number of Traps	Catch Span Times
Robinson & Robinson	1950	*Entomologist's Gazette* 1:3-20	over 50 thousand moths	1	the one night of August 20-21, 1949
Worth & Miller	1979	*J. of the Lepidopterists' Society* 33:261-264	50 thousand moths	1	May 2nd to Sept 12, 1978
Eisenbeis & Hassel	2000	*Natur und Landschaft* 75(4):145-156	6205 moths	19	May 29th to Sept. 29, 1997

While the conditions for each of the papers are not same, they do suggest a dismal trend. Different reasons for the declines are mentioned in the paper, such as clear cutting of insect habitats, the use of chemical herbicides in the environment, urban expansion, and roadway construction. What is not directly suggested is that the decline may be due to the fact that the insect populations have already been so reduced that they are having a hard time to come back.

Another example of light's effect on insects was reported by Malicky (1965. *Freilandversuche an Lepidopterenpopulationen mit Hilfe der JERMYschen Lichtfalle, mit Diskussion biozönologischer Gesichtspunkte* [Outdoor exposure tests of Lepidoptera populations with the help of JERMY's light-trap, with discussion of biocenotic aspects]. *Zeitschrift für Angewandte Entomolgie* 56:358-377.), who found that newly built and strongly lit gas stations had a high initial activity of insects for the first two years. The activity decreased quickly in later years. Eisenbeis said this is an example of the vacuum cleaner effect. There was one paper he noted that discussed insect declines and had used light traps, but it did not mention the role light had on the decline. Another paper covered the differences in catch rates between illuminated areas (city center and two housing units) and seminatural, non illuminated areas, with the illuminated areas having two to five times lower catch rates than the non illuminated areas. A main component of the foundation of our food pyramid is dissappearing.

Scheibe (1999. *Über die Attraktivität von Straßenbeleuchtungen auf Insekten aus nahegelegenen Gewässern unter Berücksichtigung unterschiedlicher UV-Emission der Lampen* [On the attractiveness of roadway lighting to insects from nearby waters with consideration of the different UV-emission of the lamps]. *Natur und Landschaft* 74:144-146.) investigated insect diversity by wooded streams far from artificial light sources using suction traps in a low mountain range in Germany. His average catch was 2600 insects, with 11,229 being the most for a single traps in one night. This, Eisenbeis said, was "further evidence that the dark zones in the landscape have a much richer insect fauna than do lighted zones."

A stunning example of the vacuum cleaner effect occurs upon *Ephoron virgo*, the Burrowing Mayfly. Mayflies are aquatic insects, spending most of their lives underwater as nymphs, molting over and over. When they undergo their final molt stage, they develop wings and leave the water to find a mate if they can avoid being eaten by fish. As they are such a favorite food of fish many artificial fishing flies lures are made to look like them. Their adult lifespans are very short, ranging from just thirty minutes to a measly few days long. Hence their order's name of Ephemeroptera ("Ephemero" means "short-lived" and "ptera" means "wing"). At their adult stage, they may not even have any mouth parts! Once they mate, the females loses their egg clutches upon whatever first surface she contacts. Their swarmming to lamps on bridges or by riversides gives them the nickname the "summer snow" as the ground near lights becomes centimeters thick with their bodies. Eisenbeis noted that one report estimated *1.5 million individuals dead in one night on an illuminated bridge's road surface*. As each female releases her eggs on the first surface

she come into contact with, this night represents an enormous loss of reproductive potential for the species. It also becomes a huge loss of food potential for other species, such as the fish who eat the mayflies and those, higher up the food chain such as humans, that depend on the fish.

Thousands of mayflies carpetted the ground around a security light at Millecoquins Point in Naubinway on the Upper Peninsula of Michigan representing another huge loss of reproductive potential for the species.
Image courtesy of Phil DeVries.

The Effect of Changing a Light's Source

Eisenbeis then discussed the data about the differences of street lighting and insect capture ratios. The data suggests that by changing lights from high pressure mercury vapor lamps (HPMV) to high pressure sodium vapor lamps (HPSV) the insect losses would be reduced by 55% and a 75%. These numbers are generally corroborated in a number of studies and they do suggest that the insects' flight to light behavior is dependent on the type of light. He went on to discuss the results due to lamp location and moon phase and then he quickly summed up the totals.

Estimate of Total Insect Mortality Near Streetlamps

Eisenbeis' calculation for the estimates are based on the assumptions of the lamp types, the average catch ratios of high pressure sodium vapor lamps (HPSV) to high pressure mercury vapor lamps (HPMV) was 0.4 (that is HPSV/HPMV = 0.4), the insect count approaching the lamp types (means were 450 for HPMV, 180 for HPSV), and that insect death counts for lamp type (150 for HPMV, 60 for HPSV). In 1998, a city about the size of Kiel had about 20,000 streetlights for 240,000 people that lived there. Then there should be about 1.2 million to 3 million insect deaths every night, or 144 million to 360 million deaths for a June to Sept. season of 120 days. Kiel's streetlight to people ratio is high compared to other cities and regions, where the other regions come out to about one streetlight for every ten persons. Assuming that ratio for Germany, population of 82 million, means there would be about 8.2 million streetlights in the country. Thus, **the total insect mortality would range between 60 to 130 billion deaths per summer season for just the country of Germany alone!**

I would like to point out that Eisenbeis' calculations only counts the streetlights in Germany, and does not count personal backyard lights, billboards, or other such lights. I also want to point out that over time, the death rate should go down, only because as the necessary insect species will have become "vacuum cleaned out" of the environment to the point that their birth rates should go down too. Thus, light pollution is not a minor problem for insect species. It is a wholesale slaughter caused by us humans, who apathetically leave lights on, that we then hardly ever use. Also the disappearance of the mayflies has been reported in other media sources like the UK's The Independent news. The report talks about how these mayflies dissappearance are causing problems with the UK's legendary trout streams.

It is often with a callous snicker that we may describe someone acting "like a moth to a flame." When doing so, we may fleetingly revel in our superior intelligence. Yet for our superior intelligence, why do we not show superior empathy? Do we ever consider then if a moth has a natural flight-to-light instinct, then maybe we should turn the light off to help this fellow species of our planet? Why do some even feel like the moth "deserved its fate?" Moths and other insects are part of the life on our planet. They are an incredibly important part of the food chain that so many creatures depend on. Insects are important pollinators, which not only helps plant species, but ultimately allows us to eat, too! Moths may lose essential defensive behaviors when near artificial light, making them vulnerable to predators. Billions of moths and other nocturnal insects are killed each year just by sheer exhaustion at being unable to escape the light if they are not immediately killed by a hot light source.

A couple of quick facts that I have learned about moths that may help you understand more about them. Being noctural and so better hidden from predators, moths rely on subtle cues to help them find their food plants or flowers to pollinate. Flowers that are white and produce a scent are as bright and as attractive as they can be during the dim light conditions of night for a moth. These are the conditions that a moth has evolved to seek out in order to find its food. Now add a white light source that is a million times brighter than a simple flower. The senses and small brain of a moth must be overloaded and overwhelmed by such radiant stimulus. It is no wonder that they act out of the ordinary, even to their own demise.

To say that Kenneth D. Frank's updated review of the literature about the effects of artificial night lighting on moths is richly informative does not do it true justice. Every paragraph is literally busting at its margins with information about the subject, which is no surprise as he had referenced over 150 papers for his review. It is difficult to point out key features of the article without entirely rewriting it outright. However, to whet your intellectual appetite to read the article, here are some select items.

Effects on Artificial Night Lighting on Moths

Source: *Ecological Consequences of Artificial Night Lighting*. Catherine Rich & Travis Longcore (eds). 2006. Island Press. Pages 305-344.

Kenneth D. Frank

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Flight Activity
Moths that fly to lights may land nearby and remain there for the rest of the night. These inactive hours represents a high cost of reproductive oppurtunity or feeding to those species who only live for a week as an adult.

Vision
Artificial lighting may distort visual images perceived by moths. Mercury vapor lighting, which gives off ultraviolet light, would enhance UV markers on flowers. However, low pressure sodium vapor light would hide such markers as it does not give off UV light. This artificial distortion of the light levels would interfere with the moth's ability to find food.

Hearing and Bats
Nocturnal moths, in those areas which are foraged by bats, often have tympanic organs to hear the bats' echolocation sounds. When the moths hears the bats signals, they make flight maneuvers to evade the bats, but not so around light sources. Not only did they stay around a light source with bats present, but some moths failed to perform their bat evading maneuvers half the time. And so, some bats more than double their food intake at lights compared to hunting in the woods.

Crypsis and Birds
Camouflage is only protective for creatures who match their backgrounds, artificial lighting can change that rule. Not only illuminates moths that should be not visible, but it also concentrates the moths around the lights. As Frank puts it: "In short, areas around artificial lights function like bird feeders."

Defence Against Other Predators
Bats are not the only animals that make use of lights to catch moths. So do spiders (some species prefer lit locations, others happen on them by chance), anoles, frogs and toads all take advantage of moths at light sources. Some hunt for the moths there, others just "clean up" the ground.

Courtship and Mating
Not only does artificial lighting competes with navigational pheromones males use to find females, it can also suppresses pheromone release. Frank first mentions seven different papers that document how light competes with and often wins out over females' pheromones in attracting males. In other cases, artificial light either suppresses pheromones or completely stops any mating activity. Such as *Heliothis zea*, which will not mate unless it eyes become dark adapted. There are a few species that are not effected this way. Female saturniids do not fly until they have release their pheromones and mated, this does not stop their flight to light afterwards, though.

Oviposition
Light traps have also been shown to capture pregnant females before they have laid their eggs. One 1937 study showed that four out of five females found in light traps were pregnant, with proportions ranging from half to all for different species. Two other studies found similar results. Having host plants nearby only increased the capture rate. The effect is so strong that the author argues that the location of the light traps must be taken into account when documenting the gender counts caught by a trap. Traps in open locations tend to collect males, while those near host plants often collect more females. It is also interesting to note that some growers have used lights

suppression of oviposition to reduce larval infestation.

Dispersal and Migration
Moths fly to light at night, some do so for incredible distances. For the species, some of these locations are utterly useless, such as to rocky islands off of Finland, to oil platforms in the Gulf of Mexico, to Abu Dhabi's deserts, or to high mountain passes in Mexico.

Circadian Rhythms
When some moths fly to lights, they may stop to rest for hours in shadows. This resembles their daytime behavior and suggests that their circadian clocks are being reset by the light. This effect is so strong that some laboratories can use it to control the functions of their moths.

Trauma
Collisions with a heated light source can kill many moths. Overheating or dehydration normally can be caused by the sun and is the probable reason moths are so active at night. Now that very danger they seek to avoid can be achieved by artificial lights, especially ones that entrap them because of their design or because of a breakage. Other traumas include damage to wings or other body parts, collisions with automobiles under streetlights or drowning under lamps over water.

This listing of the different impacts on behavior of moths caused by artificial lights at night does not even cover half of Frank's review. It is simply a phenomenal summation of knowledge we have learned and a great starting point to working in the field.

Unfortunately, a common sight of moths being attracted by a floodlight. Image usage permitted via the GNU Free Documentation License by Fir0002/Flagstaffotos

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The children's book *The Very Lonely Firefly* by Eric Carle may have been a bit more and less insightful than what the author intended. In the book, a firefly tries to find others of its kind, but keeps being distracted by various man made light sources. Finally one arrives at the page:

> When all was quiet, the firefly flew through the night flashing its light, looking and searching again.
> Then the very lonely firefly saw what it had been looking for...
> Eric Carle -- The Very Lonely Firefly

However, streetlights, billboards, up pointing tree or flag illuminating lights, and security lights never turn off all night long. Though so very close to their plight, what the author missed was that the night, for many places now, never becomes "quiet" from a firefly's point of view. Scientists are beginning to note that the fireflies can not compete with our lights and hence they seem to becoming scarce. The insect depends upon light for communication to find a mate. Fireflies may not mate normally near incandescent light because it mimics the spectrum they create when they light up. In my quick readings, I read that scientists are noting a decline in their numbers. I'll try to cover that into in more detail in a bit.

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light pollution harms insects nocturnal pollinators moths fireflys lightning bugs Florida Palm Beach County Broward County Miami Dade County