Dome lighting for insect imaging under a microscope

Peter H. Kerr, Eric M. Fisher, and Matthew L. Buffington

Abstract: The most basic element of photography is the interaction of light with the subject being imaged. In cases where magnification and clarity are of great importance, such as the imaging of insects for scientific illustration, controlling light can be especially challenging. The intense light needed to reveal microscopic elements such as setae and ultrastructural sculpturing may often overcompensate the light levels needed in other areas, especially for high color contrast and/or reflective specimens. Projecting halogen fiber-optic lights over diffusers such as Mylar or Styrofoam is one method used to overcome this imbalance successfully; however, these methods typically involve a great deal of setup time and experience. Light-emitting diodes (LEDs) are a cheap, powerful, and energy-efficient light source that is now being used more frequently in the imaging of insects under a microscope. One technique that has shown promise for quick and effective insect imaging is using LEDs in conjunction with an open dome to create a diffused, soft light arena for photography. Though commercially available illumination domes exist, creating a dome lighting system of your own is in fact easy and inexpensive. We detail how a variety of dome systems can be made using easily acquired materials and identify a few important considerations for effectively imaging challenging subjects under a microscope.

The secret world of insects is one of extraordinary beauty and delightful variation. Capturing photographic images of this beauty and variation remains a significant challenge, however, even for professional photographers. The intense light required for properly illuminating microscopic elements such as setae and ultrastructural sculpturing often leads to overexposure of other structures, especially when the subject exhibits high color contrast and/or reflective surface structures.

Entomologists who are in a position to capture high-quality photographic images of their organisms are at an advantage over those who cannot. The photographic image is a permanent record of observation and remains a critical element of entomological research. In fact, the demand for photographic images of insect specimens has probably never been greater. High-quality images are needed for illustrating specific diagnostic characters in interactive keys (e.g., Lucid), for documenting and disseminating visual records of museum type collections, for generating accurate digital illustrations (e.g., in Adobe Illustrator or Photoshop), for providing detailed habitat views of insects for general field guides, and for outreach and online dissemination of entomology-related information. Ultimately, the entire community of entomologists and stakeholders in insect-related activities benefits from high-quality insect images.

For the purposes of scientific illustration, lighting that floods the subject in soft light is often most desirable. Diffuse lighting reveals form while minimizing sharp shadowing and specular highlighting effects that tend to overemphasize specific textural elements or completely obscure them. Projecting halogen fiber optic lights through diffusers such as Mylar, passing light over rough Styrofoam edges, or constructing lighting chambers from Styrofoam are some of the methods currently employed to create soft yet intense light (Buffington et al., 2005; Buffington & Burks, 2005). However, these methods typically involve a great deal of setup time and experience. Although most light-emitting diodes (LEDs) have built-in reflecting structures to focus the light to varying degrees, LED light is naturally emitted in all directions with low spatial coherence. This means that LED light is well suited for providing diffuse lighting and is especially effective in bounced-light situations.

We have experimented with a variety of light box forms to create diffuse lighting for insect imaging and have found the best light arena is created within a hemispherical dome. In this article, we outline easy-to-build, effective, and inexpensive dome lighting systems that are suitable for efficient insect imaging under a microscope.

Building your own inexpensive LED dome lighting system

Creating a dome lighting system for insect imaging under a microscope is in fact easy and inexpensive. Although there are a number of ways to construct a customized, bounced-light dome arena, all systems have the same basic design. The reflective chamber is a hollow, hemispherical dome, with a circular viewing hole (the oculus) cut out at its top. Along the base of the dome run LED lights projecting upward, along the walls of the dome. The LEDs can be mounted low onto the sides of the dome itself, or they can be detached from the dome, affixed to the staging area. This arrangement creates a soft light arena for viewing and imaging insects. The insect is placed in the center of the dome and viewed from above, through the oculus (Fig. 1).

A dome can be fashioned from any spherical or semi-spherical vessel, with a viewing hole cut from the center. Everyday items that can be made into domes include metal desk lampshades, plastic bottle tops, spray can tops, plastic balls, storage containers, etc.

The oculus in the dome should be as small as possible, while still allowing for the largest specimens to be fully imaged through a microscope. For most insects, an oculus of approximately 25-30 mm diameter is a good place to start. As magnification increases,
less viewing space through the top of the dome is needed. To adjust the size of the viewing hole accordingly, a series of cover discs with various-sized holes in their center may be fashioned to rest on the top of the dome and restrict the size of the dome’s oculus. For use with compound microscopes utilizing low power or long working distance lenses, the diameter of the oculus should be approximately the same as the diameter of the objective lens, so that the lens may fit through the top of the dome without allowing light to escape. This will allow for play in the movement of the stage and specimen, as the disc may slide on the dome surface without the objective lens bumping into the sides of the dome. The discs can be cut out from cardstock paper and ideally are the same color and texture as the interior of the dome on their ventral surface.

An irregular surface texture may be added to the interior of the dome for enhanced light dispersal. This can be achieved using paint manufactured for texturing walls or paint used to provide grip to slippery surfaces. Generally, a matte, neutral white surface is ideal; however, we will discuss interior dome color more extensively below.

It is critically important that the LED light is a neutral or slightly warm white, with a color temperature of no greater than 5500 K. Many LED lights advertised as white are actually cool white, containing a considerable amount of blue, which is difficult to correct in image post-processing.

As discussed elsewhere (Buffington et al., 2005), an 18% photo gray card is an ideal background color. Therefore, for optimal effect, we recommend a photo gray card base and gray modeling clay for positioning the specimen. In the dome, the farther away the background base is from the focal point, the darker the background will appear in the image. Therefore, depending on the setup, the background may routinely need to be lightened for rendering the appropriate shade of grey. In our experience, laying a sheet of Mylar over the gray card base will give the desired effect. For point-mounted specimens, white points should be avoided since the white color will typically present a strong contrast against the specimen and make the image difficult to expose properly. White point mounts may also inadvertently shift the color balance and temperature of the entire image. We have found that gray or clear points are ideal. Clear points may be obtained by punching standard points from archival quality Mylar sleeves used for protecting documents.

We have found that an effective and easy lighting arrangement setup begins with a pre-fabricated LED ring light such as the KD-200, produced by Gain Express (http://www.gainexpress.net) (Fig. 2). This particular ring light has 80 warm white LEDs, is powered by 14 volts DC converted from 110-240 volts AC by a universal adapter, and has a control unit with an on-off switch and dimmer. The total cost of this unit, including shipping, is approximately $110. Importantly, the KD-200 has an interior staging space that is 36mm in diameter, which allows a specimen to be positioned at the center of the stage when the pin is held horizontally. The top of a plastic water bottle is ideally suited to serve as a dome for the KD-200 system (we use the “H2O on the GO Jr.” 1L/ 32oz. size, sold at Wal-Mart in the USA for about $1.50). This bottle is about 105mm in diameter. The entire top (immediately above the inset handle) and the 15mm-long spout are cut off, leaving a hemispherical dome with a 27mm-wide oculus. Four or six small screws (about 2mm diameter, 10mm length) are placed equidistantly around the bottom (about 10mm above the edge), so they project at right angles into the dome. These screws provide the contact point between the ring light and the dome, which rests above. The dome is spray-painted with at least two coats of white enamel. The first is textured, which leaves a ‘pebbly’ finish to enhance light dispersion inside the dome and to provide a nice surface for gripping the exterior of the dome. The second coat is flat white. Additional painting, using flat black, may also be necessary (see below). To create a foam pinning surface for the stage bottom, cardboard and gray foam discs, together measuring 70mm in diameter and approximately 10mm thick, are inserted from below. These discs are held in place against the bottom of the 56mm inner rim by the three mounting screws included with the ring light. For positioning horizontal pins, a 40mm-tall foam post may be attached with double-stick tape to the wall of the inner rim. Alternatively, gray modeling clay may be placed inside the staging area.

If a larger staging area is needed or a DC power source is preferred, using LEDs on prefabricated flexible strips is an adequate alternative (Fig. 3). The LED strips can be connected in series and mounted directly to the base of a dome. Flexible strips each house 12-24 LED bulbs and range in price from $10-20 per strip. For a relatively large dome, such as one fashioned from a typical desk lamp, at least 48 LED bulbs will be needed to generate sufficient illumination. Flexible strips require the additional task of connecting to a power supply and transformer (usually contained within the same unit; $10-20). This is easily done by soldering or crimping the wiring together and gives the flexibility of running the unit on either AC or DC power.
Customized LED dome lighting systems may also be constructed from scratch, using individually purchased LED bulbs, wiring, transformers, and other components. While we will not detail how these systems are built, the same design principles and considerations apply.

**Optimizing the system**

In some cases, there may be undesirable lighting effects created within the dome. In this section, we will outline the most commonly encountered problems and strategies to overcome them.

Specimens with smooth, reflective surfaces may cast a mirrored image of the overhanging interior space of the dome. The reflection on the specimen will show the white interior dome walls and a noticeable black spot where light escapes through the dome's oculus. The first step to reduce this problem is to be sure the viewing hole is as small as possible, by stepping down the diameter using cover discs. If this isn’t enough, a portion of the interior walls of the dome, including the area covering the oculus, may be painted matte black (Fig. 4). This will conceal the black spot by creating a reflection pattern with a linear dark/light contrast. In this regard, having LEDs affixed to the staging area, rather than to the dome itself, is advantageous. A variety of domes with different interior colorations (more discussed below) can be employed, given the specific demands of the subject being imaged, without having to re-position the specimen. It is possible that a concave two-way mirror may be used to remove the black spot cast upon a specimen by reflecting light back into the dome at its oculus, but we have not tested this idea. Of course, if undesirable effects persist despite these adjustments, re-positioning the specimen will be necessary so that the reflection is dispersed more discreetly and made more easily editable in post-processing.

Another problem with highly reflective specimens, such as some Hymenoptera and Coleoptera, is that the ring of LED bulbs at the base of the dome may be reflected along the edge of the specimen. This problem is created when the LEDs are angled inward enough to illuminate the specimen directly, from below. If the LEDs cannot be redirected away from the specimen staging area, the LED bulbs can be shielded with a strip of plastic or Mylar so that the light is projected upwards, along the sides of the dome, and does not reach the specimen directly. In some cases, the problem can be solved by simply moving the specimen closer to the stage.

Although the dome creates a chamber with exceptionally diffuse lighting, specimens that have high-contrast coloration may still present challenges for creating a balanced exposure where all elements of a specimen are properly illuminated. On the other hand, because of this exceptionally diffuse light, sculpturing details of a specimen may appear flattened due to the lack of directional light and appropriate shadowing. In both cases, adding directional lighting may correct for these types of problems. Adding directional lighting to a dome system, however, is not easily done. A hole may be pierced in the side of the dome for inserting a directional lighting source, but ideally this would require a separate power source with lights of the same color temperature with dimming capabilities, and this would probably be difficult to control. Alternatively, a translucent dome may be constructed so that external lighting, such as from slave flash units, may penetrate its walls. We have found that adding reflective surfaces, such as aluminum foil, to a section within the dome does not create an adequate directional lighting effect. However, the interior of the dome may be differentially painted so that light levels are unequal within the dome. For example, the interior half or quarter of the dome may be painted black, in contrast to the remaining white interior (Fig. 1). The dome can then be rotated to reflect light accordingly and help ameliorate exposure or flattening effect problems.

Supplemental images created from dome lighting systems, including images of the domes themselves and detailed build instructions with part sourcing, are available online [http://www.cdfa.ca.gov/phpps/ppd/Entomology/dome.htm].

**References**


Peter Kerr is Co-curator of the California State Collection of Arthropods and Senior Insect Biosystematist with the California Department of Food and Agriculture, Plant Pest Diagnostics Branch, in Sacramento, CA. His research focuses on the diversity and evolutionary history of the fungus gnats, primarily Mycetophilidae (pkerr@cdfa.ca.gov). Eric Fisher is recently retired as a Senior Insect Biosystematist with the California Department of Food and Agriculture, Plant Pest Diagnostics Branch, in Sacramento, CA. He still maintains an interest in Diptera, especially robber flies (Asilidae). Matthew Buffington is a Research Entomologist at the Systematic Entomology Laboratory, USDA/ARS, working in the National Museum of Natural History in Washington, DC. He studies Cynipoidea taxonomy and systematics, particularly of Figitidae (Matt.Buffington@ars.usda.gov).