Digital Imaging of Butterflies and Other Lepidoptera
More or less "flat" objects?

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Introduction

In butterflies and moths (Lepidoptera), wing pattern and colouration often show important distinguishing characters. For their preservation in collections, Lepidoptera specimens are pinned vertically straight through the thorax and then dried with wings outspread in a 90° angle to the pin on a setting board. When ideally set, the wings should thus all be fixed in one plane so that one is dealing with an almost flat, two-dimensional object. Depending on the original state of preservation of the specimen, the preparatory skills applied, and particularly under conditions of high levels of humidity, however, in many collection-based specimens the wings can end up at various angles to the body, e.g., hanging downwards or directed upwards in a V-shaped profile.

As part of a longer term effort to mobilize collection based biodiversity data from museum collections for a national contribution to the Global Biodiversity Information Facility (GBIF), the authors have been coordinating a database project to establish a web based information system for butterflies (Global Species Register for Butterflies / Global Butterfly Information System - GART/GloBIS; see HÄUSER et al. 2003a, 2004, http://www.lepidat.org). One of the GART/GloBIS project goals was to document and database primary
butterfly type specimens from larger museum collections in Germany. As this meant processing large numbers of type specimens at several institutions, we attempted to test and develop standards both for equipment and procedures to ensure identical working conditions when documenting specimens under different local environments. The experiences gained over the course of this project were combined with the development of standards for the ENBI project, and the techniques devised by other workers on Lepidoptera and similar groups of insects.

Lepidoptera range in size from tiny to large with wingspans varying between 3 and 300 mm. As our current project focuses on butterflies, this chapter considers techniques to digitally photograph medium-sized specimens with the smallest examples having a wingspan of about 1 cm. Techniques to photograph smaller specimens as well as microscopic preparations are not dealt with in this chapter, and require differently adapted special setups and equipment.

**General problems and requirements for photographing Lepidoptera**

With colour representation being an important aspect, two main factors always to be considered when photographing Lepidoptera specimens are lighting and background. When examining illustrations in the printed literature or on websites it is immediately apparent that a wide range of different techniques are being used, while attempts to optimize and standardize Lepidoptera photography date back to the era of black-and-white photography (DOS PASSOS 1949, KOYLER 1965). The examples shown in figs. 1-4 are meant to illustrate some of the more frequently encountered problems and challenges.

When colour photographs of specimens are to be compared with any degree of accuracy, a standardized background and light source has to be used. Black or white backgrounds are considered unsuitable in representing the extremes of the grey-scale. For the GART/GloBIS project we experimented with photographic grey cards (18% grey) as offered by KODAK and other manufacturers but found
Fig. 1. A black background can be disadvantageous for darker specimens. Here a diffuse light-source has been used but there is not sufficient light (underexposed image). Similarly, a white background is not optimal for brightly coloured specimens. – Noctuid moth (*Catocala* sp.), from SARGENT (1982).

Fig. 2. Black background with overexposed specimen. A unidirectional light-source has been positioned too low in front of the specimen resulting in undesirable shadows. The wings of set insects are never perfectly flat but reflect wing veins and folds. A diffuse or multidirectional light-source is preferable. – Noctuid moth (*Euxoa* sp.), from CALLE (1982).

Fig. 3. A bright background is usually better for both dark and pale specimens. However, unidirectional light causes shadows which can make the wing shape difficult to recognise. Nymphalid butterfly (*Agrias aedon pepitoensis* MICHAEL, syntype). From: [http://insects.oeb.harvard.edu/mcz/MPro/?-DB=Image.fm&-Lay=web-&Format=images.htm&Species_ID=16648&-Find](http://insects.oeb.harvard.edu/mcz/MPro/?-DB=Image.fm&-Lay=web-&Format=images.htm&Species_ID=16648&-Find)

Fig. 4. Even the use of several flashlights does not always eliminate shadow when a pale background is used. A ring flash positioned too close to the specimen has a similar effect. Noctuid moth (*Euchalcia stilpna*), from HACKER & RONKAY (1992).
them as generally being too dark. A pale grey plastic sheet produced as a divider for ring binders (Herlitz Article No.: 05961107; EAN No.: 4008115961106) proved to be both neutral in colour and to possess a surface structure that does not cause reflection. This material was adopted as the standard background for photographing butterfly and other Lepidoptera specimens throughout the GART/GloBIS project.

If for later image processing it is intended to digitally crop or "extract" the specimen from the image, it is advantageous to use a background with a colour which is not present in the specimen itself. Some photographers prefer a blue background (fig. 5) or a similarly intense colour for aesthetic reasons. As with colour representation in general, there will always be a subjective element in choosing the most suitable or "best" background colour for Lepidoptera.

Specimen setup

As Lepidoptera are usually pinned, the easiest way of placement is to pin the specimen directly onto the background, but then care should be taken to avoid visible pinholes (e.g., fig. 4). If the underside is to be photographed difficulties arise because now the pinhead has to be fixed somehow to the background, e.g. by placing it in a pellet of clay, plasticine or a similar medium that will hold the pin with the specimen. As most specimens are pinned with one third of the pin above the body and two thirds below, this method also results in different distances between the specimen and the background for upper- and the underside photographs. As camera distance in many cases equals flashlight distance, this results further in different background brightness for upper- and underside photographs. There are methods to overcome this problem, e.g. by placing the specimen on an elevated pane of glass so that the visible background is at a greater distance from the camera and differences in lighting become less apparent (Naumann 2001).

In the GART/GloBIS project a relatively simple setup is used which eliminates the need to pin or firmly attach the specimen to the background, and which ensures an identical distance between specimen and background for both upper- and underside pictures.
The method also allows for a much faster and more efficient handling of specimens, especially when larger numbers are to be photographed. Instead of attaching the specimen via its pin, the specimen is placed with its wings on two parallel threads of very thin fishing line (finest type available with 0.06 mm diameter), which are stretched across a wide frame or between two elevated supports. We currently prefer to use a long and wide U-shaped metal frame (see fig. 9) and to fix the fishing line tied into a loop on both sides of this frame with small magnets, which allows to easily adjust the threads whenever needed. Most small- to middle-sized Lepidoptera are sufficiently lightweight to remain perpendicular if suspended in this way. Specimens with a large and heavy abdomen, however, sometimes require additional support to keep them from toppling over.

Fig. 5. Placement of a specimen on two strands of fishing line (oblique view). Depending on light and viewing angle these supports can be almost invisible (*Colias* sp., Pieridae).

Against a pale grey background, the fishing line is often invisible in the picture (see figs. 7-8). If still visible, the resulting two fine white lines can usually be eliminated easily later from the image. If handled carefully, there are no adverse effects on the specimens except for the occasional loss of a few scales. Thus, only the threads need to be wiped from time to time as some wing scales will adhere to them during the course of work.
Lightweight objects such as locality labels, bar codes or scale bars can also be placed on the fishing lines to be photographed together with the specimens (figs. 7-8). If specimens do not have their wings in a flat position or are not pinned in a satisfactory way with an approximate angle of 90 degrees to the body axis, however, this setup will also face problems in facilitating a perfect picture (figs. 6-8).

Fig. 6 (right). A problematic specimen. The wings are not in one plane and the specimen is pinned at an irregular angle (*Agrodiaetus* sp., Lycaenidae).

Figs. 7-8 (below). The dorsal and ventral view photographs of the same specimen. Note that fishing line supports are barely visible (*Agrodiaetus* sp., Lycaenidae).
Light source

A large variety of lamps and flashlights has been used in Lepidoptera photography. To eliminate shadows both on the wing surface of the specimen (fig. 2) and on the background (fig. 3) a diffuse or multidirectional light source is clearly the preferred option. However, iridescent colours produced by the reflection of light in the wing scale microstructure can generally be captured better with unidirectional light sources (e.g. fig. 3).

One of the most serious problems in the photography of spread Lepidoptera specimens is the presence of shadows cast by the specimen itself onto the background. There should be as little shadow as possible – ideally none at all – so as not to distract from or to diffuse the actual specimen. A medium-sized ring-shaped lamp is the best way to ensure an almost shadow-free image. For live insects, a conventional ring flash mounted onto the camera lens is a good option. In the case of pinned and spread specimens, however, a ring flash often causes a diffuse shadow around the specimen due to its small diameter (fig. 4).

The ring lamp solution: The best option for producing shadow free pictures of spread Lepidoptera seems to be a circular light source that has a larger diameter than conventional ring flashes. Circular fluorescent light-tubes are available commercially in several sizes, and are not very expensive. These tube lights, however, mostly produce either the extremes of the usual "warm" spectrum tending towards yellow or rather "cold" bluish light, which both lead to serious problems in colour representation. As a special high-end product, however, a fluorescent light tube with a so-called "full spectrum" with a light temperature of 5500 K is also available (VITA-LITE, DURO-TEST), which comes very close to natural daylight. Although considerably more expensive than common fluorescent light tubes, we found this lamp an ideal solution both for allowing shadow free images, and good colour representation.

Initially, this lamp was chosen because the GART/GloBIS project had been planned in the late 1990ties, when the photographic documentation was still expected to be carried out using conven-
Fig. 9 (above). The circular light tube and a specimen set up for photography, shown without container for clarification. The supporting threads of fishing line are stretched between the upturned ends of the metal frame. Background papers can be exchanged easily.

Fig. 10 (right). Lamp detail.

tional cameras with colour slide film. With the increasing availability of medium-end digital cameras for the general market, these soon proved to be sufficient for the purposes and requirements of the project. We first used the NIKON coolpix 990, later the NIKON coolpix 995, and the NIKON coolpix 5700. All these camera models possess a white balance function which no longer makes a full spectrum lamp a requirement for good, natural colour representation. A full spectrum light, however, is still very helpful whenever using
Fig. 11. Comparison of color spectra of natural light, bulb light and two types of fluorescent lamps.

cameras with colour film or when studying and comparing specimens with the naked eye.

The "light box" developed for the GART/GloBIS project: To facilitate the standardized processing of large number of specimens for the GART/GloBIS project for a longer term, these components were integrated into the construction of a durable special "light box", which since has been turned into a commercial product. The main function of the light box is to provide a stable, permanent setup for the circular fluorescent tube to be left for specimen photography at a central location within the collection for continuous use.

To prevent the lamp light from directly entering into the lens of the camera (and also into the photographer's eyes) the light tube is mounted inside the top of a rectangular aluminium box (36 x 33 x 20 cm) with a round opening on top which is slightly smaller in diameter than the circular light tube (figs. 12-14). The aluminium frame has a structured surface to reflect and further diffuse the light, and the box is open on two sides to allow the specimen setup to be moved easily across the bottom of the box. An electronic ballast built into the box provides for flicker-free light, and a switch allows the box to be plugged in without the lamp to be turned on all the time.
Fig. 12 (right). The ring lamp mounted inside the "light box".

Figs. 13-14 (below). Working with the "light box".

The “light box” was initially designed by WOLFGANG ECKWEILER (see ECKWEILER 2001), and is currently produced and commercially marketed by the company of FRITZ WEBER (Stuttgart) (www.fritz-webler-entomologiebedarf.de/21904.html). The company now also offers a collapsible model for easy transportation, in which the two side boards can be folded inside protecting the lamp and resulting in a size of 39 x 33 x 7 cm.

With this setup and equipment, specimen photographs can be taken freehand which significantly accelerates the progress of work when photographing larger number of specimens. When using camera settings requiring longer exposure times or for other special purposes, a tripod mount is still advisable and can be added easily to the general setup.
Naming image files

When photographing larger number of specimens, the need for an efficient administration of the resulting images requires some consideration in naming the individual image files. As at the beginning of the GART/GloBIS project plans for globally unique identifiers (GUIDs) or other international standards for image file names were still in their infancy, we developed our own standards for image file names for the purpose of the project. Apart from the basic requirement for creating unique names for all files, file names should preferably also contain information about the image content, for which the taxon name was thought to be most useful in case of type specimens. Accordingly, file names of specimen images for the GART/GloBIS were created along the following scheme, which is currently still applied for the project:

Example: **Zerynthia rumina** ssp. **lusitanica** Bryk, 1932  Type

lusitanica_Bryk_Zerynthia_rumina_MNHU_1A.jpg

A = upperside
B = underside
C = labels

taxon author
genus (and species) as in original combination
museum acronym
specimens numbered consecutively

Final considerations

The experiences gained during the GART/GloBIS project with the setup and standards for photographing butterfly specimens presented here have been overall very positive. So far, about 5,000 type specimens in more than a dozen museum collections have been documented, which resulted in more than 16,000 image files. The images have been used both for digital applications such as web-based databases (www.lepidat.org; http://www.biologie.uni-ulm.de/systax/) as well as printed end products (e.g., Häuser et al. 2003b, 2004), without yet facing the need to change any of the applied standards or techniques. Meanwhile the "light box" has been acquired by several larger museums and is available for use by re-

Despite all efforts towards optimized standards, however, there will always be cases to which they cannot be applied and where creative, sometimes instant solutions are called for. This is certainly the case with many damaged specimens which must be handled as little as possible, but sometimes also with specimens preserved in an unusual fashion (figs. 15-16).

Figs. 15-16. Problematic cases: Specimens like these 18th century butterflies that are severely damaged or set/pinned in very unusual fashion cannot be accommodated by fishing line supports.

Fig. 15 (above). Type of *Papilio aurota* FABRICIUS, dermestid-eaten.

Fig. 16 (right). Type of *Hesperia flaccus* FABRICIUS, "pinned" on a thorn.

When further considering colour standards it should also be noted that it will practically be impossible to achieve perfectly identical colours for all printed products and on all computer screens due to
different hardware properties and varying screen settings (see also MORRIS on "Colour Management", in this volume).

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