Annex A: Guidance for Assessing Digitisation Equipment

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Overview

This document gives an overview of the equipment involved in Pinned Insect, Microscope Slide and Herbarium Sheet Digitisation/Imaging and provides guidance about how potential options can be assessed and chosen for their suitability.

Assumptions

The guidance provided assumes that images taken are solely intended to provide a digital surrogate overview representation of, for example, a single pinned insect specimen and its associated labels. It is not intended to also provide solutions that could be useful for imaging of diagnostic or other smaller features that may require magnification. It is also assumed that suitable computing equipment will be available, though a list of specifications known to perform well is included for reference.

Equipment

There are four primary pieces of equipment that need consideration when looking to undertake any photographic digitisation work:

1. **Camera**
    a. Body
        i. Sensor
        ii. Power Sources
            1. DC Coupling
            2. Additional battery packs and chargers
        iii. Connection options to Computer Equipment
            1. Shooting Tethered
                a. Tethering Software
                b. Post-production software
    b. Lens
        i. Focal Length and Type
2. **Copy Stand**
    a. Base Size
    b. Length of Column
3. **Lighting Solution**
    a. Lightboxes
    b. Lamps etc.
4. **Standardisation equipment**
    a. Scale bars
    b. Colour charts

Additionally, there are various other pieces of kit (e.g., forceps etc.) and consumables (e.g., insect pins, herbarium capsules etc.) that may be of use whilst undertaking any Digitisation Imaging project. Requirements

for these will likely vary too greatly across potential collections to offer in depth guidance but a 'kit list' of potentially useful items is included below for reference.

Camera

Body

The primary reason for separating considerations for Camera bodies and lenses is due to the potential advantages, and time savings, of tethered imaging (where the camera is connected to a computer for remote control such that, for example, you press a button on the keyboard to take the image or move files). As far as we are aware, this is beyond the scope of compact or bridge cameras (those with built-in lenses) and so these are not considered here.

Depending on the specimens you are looking to digitise there are potentially different specifications and parameters that should be considered but these will largely be influenced by specimen size, desired image file format and resolution.

Equally, with the advent of mirrorless cameras as the natural successor to DSLR (Digital Single-Lens Reflex) cameras, over the last five or so years, there is also the consideration of whether opting for a more modern option will stand you in good stead should any replacement be required due to differing lens mounts across companies and across product lines within the same company.

There is also the factor of shutter lifespans to consider. Where DSLRs tend to fall somewhere within the range of 100,000 – 200,000 shutter actuations, Mirrorless cameras have a wider range of 100,000 – 500,000 actuations and, indeed, if a mirrorless camera can be set up to utilise an electronic shutter, this can potentially prolong the lifespan of a camera, when compared to using a mechanical shutter.

Sensor

A camera's sensor is arguably the feature by which it will be most judged as it is the interplay between this and any lens that will provide an image.

The resolution (megapixels, MP) dictates the amount of detail a camera can capture, with higher resolutions generally leading to sharper images and more detail. However, this will also be effected by the sensor size – if we compare full frame sensors (replicates 35mm film – c.36x24mm) with smaller sensors (e.g., Micro Four Thirds – c.17x13mm, or APS-C – c.23x15mm), then in instances where two cameras have the same resolution, but different sensor sizes, it will be the case that the camera with the smaller sensor will have a higher density of pixels (MP/cm^2).

This may lead us to the conclusion that this may allow for more detail to be captured with a smaller sensor but, whilst that is to some extent true, it does not appreciate that this necessarily requires for each individual pixel to be smaller than those present on larger sensors – and where a pixel is larger, it is able to capture more light, therefore reducing overall potential noise within an image and increasing the potential dynamic range of brightness and colour within an image.

There has also been the advent of 'pixel shift' and high-resolution modes within some cameras that allow for multiple images to be taken and processed within the camera, to produce far higher effective resolutions than a sensor alone might dictate it is capable of.

From a digitisation standpoint, it is therefore important to consider both what is being imaged (in terms of size) and what necessary detail is required to provide a suitably good image. Due to differing sizes of Entomological and Herbarium specimens and that images:

1. Will primarily be viewed on a computer screen
2. Are primarily used to see an identifiable representation of the specimen and its labels

It is likely that a camera, with a sensor of a given size, should have a higher resolution when imaging Herbarium specimens as it is likely that the comparative zoom necessary to adequately read label data is higher than that found with Pinned Entomological specimens.

For reference, NHMUK has used a variety of camera brands and models across both workflows, providing good results, with ranges of sensor resolutions, and sizes, as follows:

1. Pinned Insect and Slide Specimens
    a. C.20-50MP
    b. APS-C and Full Frame sensor size
2. Herbarium Sheet Specimens
    a. C.50-150MP
        i. via the use of High-resolution modes, this has recently been increased to c.180MP
    b. Full Frame and Medium Format sensor size

Power Sources

There will likely be the need for additional power during the course of a full day's digitisation, due to cameras being switched on (other than, say, during lunch) and in constant use.

Depending on the model and make of any digital camera, there are potentially two options available:

1. DC Coupling

This is effectively a dummy battery that lives in the battery slot of a camera and, with the addition of a suitable AC adapter, allows for a camera to be constantly powered from the mains plug socket.

2. Additional battery packs and chargers

This is potentially a simpler and cheaper option (though not all modern digital cameras appear to come with distinct chargers, so this can be an additional expense), though may result in more disruption to imaging as a camera will likely need to be unmounted in order that batteries can be changed and put on charge. This also has the potential for further disruption if batteries are not monitored and kept charged.

Connection options to Computer Equipment

Whilst it is feasible to undertake imaging and not be connected (tethered) to computer equipment, this will require purchase of additional memory cards for image storage (depending on productivity, potentially requiring changing throughout the working day) and time spent uploading these to a computer system for potential further post-processing due to the differences between viewfinder/camera screen and computer screen lighting and composition.

Shooting whilst a camera is tethered to a computer is strongly recommended so that any necessary adjustments can be readily recognised and made throughout the working day, with images immediately available for viewing, suitably renaming and, in turn, uploading for ingest into Collections Management Systems or equivalents.

Primarily, digital cameras will connect via USB to computer equipment. Increasingly, this is done via supplied USB-c cables so it is good to ensure that any computer has this connectivity available, or a USB-A to USB-c cable will need to be purchased (cable purchase may also be necessary due to length of supplied cables being insufficient in combination with the layout of workstations).

Depending on the brand of camera chosen, there will likely be tethering/remote shooting software available to download from the brand website. This software will normally allow for full control of changing desired camera settings (ISO, shutter speed and white balance), imaging without touching the camera (depending on the lens, this may also include the ability to adjust aperture size and autofocus - manual focussing may still be necessary) and determining image file format and some broad metadata fields.

For the most part, it is better to image in such a way that post-processing is not necessary. However, on occasion, this cannot be avoided and so some may be required to produce the image you require (e.g., via cropping, adjusting colour etc.), there are myriad purchasable and open-source options within this field and so, some research may be necessary depending on your particular needs.

Lens

The primary consideration when looking to purchase a lens is that the mount matches that of the camera with which you are intending to use it. It is possible to purchase a variety of mount adapters, either proprietary or third-party, that may allow for these parts to be connected but I would advise against that unless you already have a good lens and are looking to use it with a new camera body.

Similarly, it is possible to use full-frame lenses with smaller sensors (e.g., APS-C). In this case, the sensor will not use the lens' full field of view and so, there will be an element of cropping that acts similarly to zooming in on the image and effectively adjusting how the focal length of the lens should be considered. In this instance, this can be calculated by multiplying the focal length of the full-frame lens by the 'crop factor' of the camera (a ratio representing the difference between the actual sensor size and a full-frame sensor).

As the focal length has been alluded to above, it is necessary to consider what this means. This is the distance (in mm) between the camera sensor and the 'nodal point' of the lens used (this is effectively where light appears to converge).

For digitisation, the primary consideration here is whether this should translate to a 'zoom' (the focal length is variable, noted by a range of focal lengths e.g., 70-350mm) or 'prime' lens (the focal length is fixed, e.g., 80mm).

Whilst a zoom lens may allow for fewer lenses to be needed across a wide variety of photography tasks, digitisation often concentrates on similar objects that are suitably similar and, as overview images are often the sole pursuit of digitisation, can be imaged utilising a single lens. As such, prime lenses are recommended (this also removes the possibility of lens weight causing the focal length to change throughout the day due to cameras being inverted to shoot from above a specimen).

For focal length this can be considered that, at a given length from any object, a lens with a shorter focal length will capture a wider/larger field of view than a longer focal length.

One other potential factor that should be considered when choosing a lens is its available aperture capabilities. Many macro lenses will have the ability to open the aperture more fully to allow more light into the camera when close to the specimen (noted by a smaller f number). However, this also has the effect of reducing the depth of field within the image, so it is better to shoot from somewhat further away (and with adequate lighting) to ensure the entirety of a specimen is in view and in focus. As such, for particularly 3D items, a higher possible f number may be advantageous when all these aspects are combined.

To this end, the NHMUK has used a variety of lens brands and models across workflows, providing good results, with focal lengths and apertures used, of:

1. Pinned Insect and Slide Specimens
    a. 90 or 100mm macro prime lenses
        i. Aperture c.F9 – F14
            1. This may be F5.6 – F7.1 for microscope slides
    b. For some larger specimens this has been reduced to 50mm
        i. Aperture c.F11
2. Herbarium Sheet Specimens
    a. 40, 63 or 72mm macro prime lenses
        i. Aperture c.F5.8 – F6.5

With some more modern cameras, similar to 'High-resolution' and 'Pixel Shift' modes to increase effective resolutions, there are focus bracketing shooting modes that take several photos, automatically adjusting the focal point to capture separate slices in focus and then process/stack them within the camera to allow for a shorter depth of field to be utilised if desired.

Copy Stand

Holding a camera still is vital for specimen photography and, with the likely kit and settings required for this, is difficult to achieve manually and particularly for protracted periods across a working day.

Whilst tripods may be useful for large scale, heterogeneous photography, when photographing Pinned Insect or Herbarium Sheet specimens, a copy stand can provide consistent and easily reproduceable results and so these are recommended.

The primary considerations when choosing a copy stand should be:

1. The size of the baseboard that your specimen will be placed on
    a. smaller specimens do not necessarily require a large base but it is advisable that larger specimens should not hang over the edges of a small baseboard
    b. These normally have adjustable feet to allow for level imaging
2. The height of the column attached to the baseboard
    a. Depending on the size of your specimens and the focal length of your lens, this may need to be longer
        i. NHMUK have experience of using
            1. 1m columns for Pinned Insect/Slide workflows
            2. 1.2 and 1.5m columns for Herbarium Sheet workflows
                a. Do note that when 1.5m columns are mounted to bases, they can be quite tall and so adequate ceiling clearance is necessary when placed on a suitable desk or table to accommodate these
3. The 'capture arm' that screws to the tripod mount of the camera, holding it rigid and parallel to the specimen
    a. Normally this is adjustable and provides vertical movement above the specimen to get the best shot
    b. Some are adjustable to alter the distance of the camera from the column and so the view over the baseboard and specimen
    c. Others can be rotated so that cameras shoot at 90 or 180 degrees to the column
        i. This can be useful to limit necessary rotating of images in post-processing but is not essential

Lighting Solution

There are two primary options for lighting when considering pinned insect, slide or herbarium sheet imaging – lightboxes or lamps.

Lightboxes offer a light source that is surrounded on some or all sides, with the ability to place the specimen inside and image from above. They may or may not have a way of closing off all other extraneous light than where the camera views the specimen. This can result in reasonably well distributed light and, where outside light is minimised as much as possible, constant lighting conditions. These have historically utilised halogen ring bulbs for illumination (c.35W) but more modern options (often offered as 'product photography' cubes or lightboxes) utilise strips of LEDs to provide lighting.

An interesting facet of some white LED lighting is that the colour 'warmth' and brightness can be adjusted to provide near daylight conditions which can make calibration somewhat easier.

The other primary option for lighting is to use lamps – these can either be freestanding or sometimes bolt onto copy stand base boards. Depending on the location of a workstation, lamps can be unduly influenced by ambient light if not sufficiently powerful (lamps should be used in pairs providing light from each side to minimise shadows and angled at c.45° from the specimen on the baseboard).

In instances where a larger field of view is required lamps may be beneficial as large, 'off the peg' lightboxes are not commonplace and so, when available can be prohibitively expensive.

There are potential DIY options as shown by the open source TORCH Light Box that utilises aluminium T slot extrusion and LED strips but, whilst interesting, there is not a formal bill of materials or guidance for this premise to be adequately, or quickly, replicated.

Standardisation Equipment

The final pieces of equipment that are desirable for digitisation are those which allow for standardisation and measurement. Most digitisation is undertaken with a scale bar and sometimes also a colour calibration chart.

Scale bars can either be purchased, or with some suitable technological aptitude and ensuring that no alteration to scaling occurs at point of printing, produced in-house.

It is also feasible to buy, or potentially produce, colour calibration charts (though the technical knowledge involved in producing them in-house may not be present or feasible depending on colleagues or printing capabilities).

The only further considerations for these is whether they are always necessary for every image (NHMUK has a history of always utilising scale bars within mass-digitisation but only uses colour charts as standard within Herbarium digitisation) and the potential size of any scale bar or colour chart, as this will often have an impact on the associated costs.

Additional equipment information

Computer Specifications

If you are looking to purchase computer equipment for regular digitisation use, without substantial post-processing, the following specifications have been found to be reliable:

- 3.6 GHz CPU
- 16GB RAM
- 1TB SSD hard drive

For a system with more processing capacity (intended for increased post-production):

- 3.6 GHz CPU or better
- 32GB RAM
- 2TB SSD hard drive

24- or 27-inch monitors have been found to work well across both of the above types of computer setup.

In both instances, and depending on how quickly any images will make their way to a given repository, it may be beneficial to investigate additional external storage. Portable external hard drives with a capacity of c.4TB per workstation have proved useful, though, depending on the scale of any operation, there may be the argument for researching the possibilities of network attached storage (NAS).

Similarly, workstations may benefit from having a suitable barcode scanner/reader (1D/2D barcodes depending on workflow) to allow these to be scanned as necessary.

‘Kit List’ of potentially useful additional equipment and consumables

Please note your own curatorial or conservation teams may also be able to advise on suitable tools and materials.

Pinned Insects/Slides

1. Entomological forceps – useful for handling removing specimens from drawers, or unit trays and general handling

    a. There may be benefit in investigating curved Castroviejo needle holders (often used in ocular or dental surgery settings) as these offer a similar solution but with finer tips than standard entomological forceps
2. 'Sharp' Forceps – useful for removing labels from pins and handling barcodes etc. These come in a variety of sizes, 4 & 5 being potentially the most useful
3. 'Soft' 'Storkbill' Forceps – particularly useful for handling broken parts of specimens to minimise further damage
4. Glassine envelopes – these come in various sizes and can be utilised to conserve broken entomological material (e.g., Lepidoptera wings)
5. Gelatine capsules – also available in various sizes and for the conservation of bulkier, broken entomological material (e.g., abdomens)
6. Archival ink pens – useful for noting anything on labels within a drawer or for adding data to specimen labels
    a. Come in a variety of thicknesses with 0.20mm being particularly useful
7. 2mm EVA foam – as long as a high-density option (smooth, without pores) is found this provides a nice, consistent background for specimens and labels to be imaged against
    a. An inert light grey has been found to be a good background colour
8. Plastazote sheets – useful for unpinning specimen labels on and as the backing for EVA foam within imaging setups
9. Insect pins – available in various lengths and thicknesses, useful for e.g., cross-pinning specimens
10. Cabinet points – short pins useful for e.g., pinning labels or notes into unit trays or collection drawers as necessary

It is assumed that suitable cabinetry, collection drawers and unit trays are available where necessary.

Herbarium Sheets

1. Smoke Sponges – useful for removing 'smoke' from herbarium sheets, particularly to ensure barcodes or capsules stick well
2. Four flap Capsule folders – available in a variety of sizes and useful for glueing to herbarium sheets to house loose specimen material
3. White neutral pH adhesive – useful for e.g., glueing capsules to herbarium sheets
4. Minarette spatulas – useful for e.g., suitably manoeuvring or manipulating loose specimen material
5. H pencils – useful for e.g., noting taxonomy or vice county codes on herbarium sheets or folders, or providing translation of the label where necessary.
6. Brass paperclips – securing bulky capsules closed, securing loose notes to the sheet if attaching it via an adhesive is not possible/recommended

It is assumed that suitable cabinetry, folders and specimen sheets are available where necessary.

Universal Consumables

1. Barcodes – these are added as an identifier that links a physical specimen to its digital record, as well as being used to encode key data for imaging such as taxonomy based on information in your Collections Management Systems (CMS). Both Code 128 (1D, 'normal') and Data Matrix (2D, looks like QR) barcodes may sometimes be ordered e.g., to meet archival adhesive standards, and sometimes printed in house. Further information about the use of barcodes can be found in the DiSSCo Digitisation Guides .
2. Scissors
3. Scalpel blades and handles
4. Archival paper/card
5. Pens/markers
6. Post it notes
7. Lens tissue papers
8. Paintbrushes

9. Stapler and Staples
10. Masking tape
11. Blu-tack
12. Box folders
13. Screen wipes
14. Nitrile/disposable gloves of various sizes

Additional useful sources

https://www.eizoglobal.com/library/management/adobergb/index.html - this article is useful comparing Adobe RGB and sRGB colour gamut.

https://bdj.pensoft.net/article/148861/list/8/ - An example of a Herbarium digitisation workflow, including equipment used.

https://dissco.github.io/DataManagement/Software/Software.html - useful guide to existing software that may be useful within a program of digitisation.

https://commons.wikimedia.org/wiki/File:Photo_lenses_with_a_focal_length_and_angle.svg - image is useful to show the relative angles of views across different lens focal lengths.