Macrophotography- The technical background

By Brian Ferry

MACRO is 'extreme' photography and as such, has inherent problems which increase with the magnification of the image on the sensor (**m**). Depending on the degree of hi-tech needed, solutions vary from cheap (£↓) to costly (£↑). Basic macro work can work well with cheap basic kit, provided the system is designed for macro work, but more extreme work needs more expensive hi-tech equipment. Thus you need to match your camera to your plans and available budget.

For example basic work might involve photography of a stamp collection where **m** = 0.5 to 1, in which case some of the potential technical problems are unimportant. But more extreme situations such photographing butterflies hand-held, may need a 200mm-equivalent macro lens with Internal Focussing (£↑) and Image Stabilisation. Most MACRO work lies between these examples, as will the problems and solutions.

Problem 1-Possible loss of light at the sensor
Some lenses focus by extension, i.e. moving the optics further away from the sensor. The rear element projects light onto the sensor, and lens-extension dims the image thus more exposure is needed. Telephoto lenses lose much more light when extended – look at the iris from the front and back of the lens, if the aperture appears smaller when viewed from the back, then the ratio of f/b is an additional factor for extra exposure. Non-telephoto designs avoid this effect.
Solutions

- For basic work this is usually not a problem as the TTL-metering copes. More extreme work needs a fast speed as the subject is moving. Lenses which focus without moving the rear component and so do not incur dimming are some macro zooms and/or macro lenses with internal focussing, which is hi-tech but £↑.
- Other ways of close-focussing are to use a **teleconverter** to magnify the image with the close-focus of main lens. A teleconverter requires more exposure as the image dims. For basic work again this is no problem since the TTL metering copes. In more extreme work problems with light-loss may preclude the use of teleconverters.
- A close**-up lens** placed in front of the main lens gives close- focussing. The combined lens has a shorter focal length and the actual aperture is less than that marked on lens, which compensates exactly for lens extension so no extra exposure is needed. Single-element lenses upset lens corrections so quality suffers. Two-element achromatic lenses (Canon, Nikon) are expensive but give better resolution with **m**>0.3.
- The ultimate in close-up lenses is a 50mm standard lens reversed on to a 135mm or longer lens to avoid vignetting. The long lens controls the aperture, the reversed lens is used wide-open. Such **stacked lenses** give excellent definition because the close–up attachment is a high-quality lens. Use a coupling ring and step-up/down rings to screw the lenses together (see S2), and you don't need an OEM lens to reverse – any quality lens will suffice, and f1.8 is better than f1.4 and £↓. **m** = 135/50 = 2.7

Problem 2 - Loss of Quality
Most lenses for ordinary use are designed to have optimal resolution with fairly distant subjects and so the subject and image distances have a ratio 100:1 or greater. In MACRO, if **m** = 1, this ratio is 1:1 due to close-focussing, so the lens is working outside its design specifications and aberrations are under-corrected, giving a poor quality image.
Solutions
Use lenses designed for similar subject and image distances, or use an ordinary lens differently.

- For basic work use an enlarger lens or reverse-mount an ordinary lens, for adaptors see www.srb-griturn.com (£↓). Such kit operates only manually as the body – lens communication is interrupted, so the camera body needs to be able to work this way. Reverse mounting also increases the magnification as the lens doesn't fit inside the mount and thus is extended.
- More extreme work needs lens-body communication, so a properly designed macro lens will need to be used i.e. a non-telephoto lens designed for close-up work, preferably internal focussing and image stabilisation (£↑).

Problem 3 - Limited depth-of-field (D-o-f)

The apparent depth of field of an image is due to limited resolving power of the eye. D-o-f increases as the aperture of the camera lens decreases (i.e. the F-number increases) and for normal photography the d.o.f is about 1/3 in front of the plane of focus and 2/3 behind it. In MACRO the total d.o.f decreases sharply as **m** is increased and the depth of field in front of the plane of focus is only slightly less than that behind it. The d-o-f depends on many factors including lens and sensor design and the extra magnification of the final image initially recorded at a particular value of **m**. For example, with **m** = 1, at f22, and 10x magnification of the image when printing, the total d-o-f is calculated to be 2.6 mm, distributed almost equally about the plane of focus. So for a 3-D subject at life-size on the sensor, the point of focus needs to be half-way through its depth. Selection of the aperture isn't easy, as using the d-o-f preview makes the image darker, and it's difficult to see which part of the subject is in focus. This technique is OK for seeing disturbing highlights in the background, but for accurate selection of the F-number, tables of d-o-f are helpful. Info on devising complete d.o.f. tables is available.

Solutions

- For basic work there is normally no problem with d-o-f in a 2-D subject. Use a focus magnifier and select the aperture for best definition, usually 2 stops down from wide-open.
- In general, there is no solution to the problems of limited d-o-f in 3-D subjects. Stopping down too much incurs reduced quality due to diffraction. Image-stacking using different images at different points of focus helps (www.heliconsoft.com). See also John Bebbington FRPS, The Iris (Magazine of Nature Group, RPS), 102, Winter 2008.

Problem 4 - Susceptibility to shake and vibration

Shake is due to a wobbly photographer and vibration is due to the mirror and shutter, both of which move linearly and when these come against stops their momentum sets up vibration. Both shake and vibration blur the image on the sensor as the camera moves relative to the subject. Because of magnification of the image, at **m** =1, movement is lifesize!

Solutions

- Ideally always use a camera support, tripod or macro stand to avoid shake. To avoid vibration, spurn shutter speeds **1/15** to **1/4** sec as the vibrations occupy much of these times. Prolong the exposure time so that the camera is steady for most of the time if necessary by using a ND filter. Also minimise the moving masses by using mirror lock-up. Increase the non-moving mass of the kit on its support by laying a weight on top of it (bean bag or brick?). All relatively £↓.
- For more extreme work conventionally, the minimum shutter speed to avoid shake is 1/focal length, i.e **1/200** sec for 200mm lens. In MACRO, the rule is:- speed = 1/1000**m**, i.e., for **m** = 0.5, is **1/500** sec. According to the 'Sunny f16 Rule', in photography of a butterfly in cloudy conditions at f16, **1/500** sec is possible only with an ISO of 2000. So this work would normally need IS to allow a slower speed and a quality low ISO, and also avoidance of light loss by using a macro lens with IF, so £↑.

Further reading

1. The manual of close-up photography. Lester.Lefkowitz 1979. Amphoto. ISBN 0-8174-2456-3. Zany images but good text, covers everything c. 1989. No digital.
2. The book of close-up photography. Heather Angel FRPS 1983. Ebury Press, ISBN 0-85223-265-9. Excellent book by one of founders of RPS Nature Group. No digital – but does this matter?
3. John Shaw's Closeups in nature. The photographers guide to techniques in the field. 1987. Amphoto. ISBN 0-8174-4052-6. Magnificent images and most helpful comprehensive text. No digital.
4. The complete guide to close-up and macro photography. Paul Harcourt Davies 1998. David & Charles. ISBN 0-7153-0800-9 Excellent, touches digital. Superb images.