MACRO PHOTOGRAPHY

Introduction

Newcomers to macro photography have to deal with a great deal of new terminology as well as dealing with the particular equipment and techniques that are required in macro photography. Inevitably, this means that there are many questions that arise related to macro terminology, techniques, and equipment. Some of the more commonly asked questions about “Macro” follow in the form of a FAQ, with appropriate and reasonably accurate.

These FAQs exhibit some Nikon-centricity; however, if you ignore that aspect, they should be equally applicable to macro work using other SLR systems.

The FAQs

Q: What is a macro lens?

A: Macro lenses are optimised for close focusing, and will give a magnification of at least 1:2 (the image on the film or sensor is half life-size) and more commonly these days, 1:1 (the image on the film or sensor is life-size), unaided. These lenses are usually, but not always, "prime" lenses (i.e., lenses of a fixed focal length), but there are a few examples of zoom lenses, such as the Nikon 70-180, that were designed specifically for macro use. True macro lenses are optically excellent; they are very sharp, have good contrast, and minimal distortion.

The term "macro" is often misapplied on general purpose zoom lenses where there is a close focusing facility, but the magnification achievable is generally 1:4 or less, and the optical performance is usually not in the same league as would be expected from a purpose-designed macro lens.

Q: My zoom lens has a "macro" setting. Will this be useful for macro photography?

A: Most zoom lenses with a "macro" setting really are not worthy of the "macro" label, although in some cases, general purpose zooms can have a fairly respectable performance at close focus and can be a useful backstop when you are travelling light. Examples are the Nikon 28-200 G and the Nikon 18-200 AFS-VR, both of which have respectable performance at reasonably close focus distances, and the Nikon 28-105 that has the unusual ability to focus down to 1:2. However, it is rare to find a zoom lens that gives better than about 1:4 magnification, and the sharpness and image distortion will generally not be up to the standard you would expect with a dedicated macro lens. The one real exception is the (now sadly discontinued) Nikon 70-180 which was designed for macro use and is optically excellent.

Q: What is the best focal length lens for macro work?

A: This is something of a "How long is a piece of string?" question. Macro lenses are available in a wide range of focal lengths; most fall in the range 50mm-200mm, but there are exceptions. For example, although not strictly a macro lens, the 10.5mm Nikkor can focus on

objects only a few cm from the front element, so it certainly qualifies as a "close-up" lens, although its magnification at closest focus is not what you would expect from a macro lens. The choice of focal length is very dependent upon the kind of subject that you wish to photograph, the format (35mm, FX, or DX) that you are using, and the kind of effect that you wish to achieve. The considerations here include:

- If you are photographing nervous or dangerous creatures that might be "spooked" by the close proximity of a lens, then longer focal length lenses are advantageous, as they will give a greater working distance between the lens and the subject.
- Longer focal length lenses are more difficult to hand-hold than shorter focal lengths (this is what we expect from conventional photography, but the effect is more pronounced at close focus distances). Therefore, when using longer focal length lenses it may be necessary to use a tripod or to use additional illumination (e.g., flash) so that higher shutter speeds can be used to mitigate camera shake.
- When working in a studio setting, shorter focal length lenses are often more convenient to use, as the shorter working distances are often more compatible with the space constraints in a studio. The lenses in the 50-60mm focal length range are, for example, ideal for photographing documents or flat objects like stamps in a studio setting.
- The focal length of the lens has an effect on the degree to which the subject in the foreground is isolated from the background. Choosing a shorter focal length lens will tend to reduce the degree of isolation - more of the background will be "in shot". With a longer focal length, it is easier to isolate the subject from the background. However, the degree of isolation that is appropriate depends on what you are trying to achieve pictorially, and there are other techniques, such as controlling the depth of field and the positioning of the camera relative to the subject that also affect the degree of subject isolation that can be achieved. (See also What is the relationship between the focal length of a lens and its angle of view? below.)
- When using a DX format body, the lens behaves, for most practical purposes, like a lens of 1.5 times the focal length on 35mm or FX format bodies. The maximum magnification achievable with the lens isn't affected; however, as the DX frame is smaller than the 35mm and FX frame, if an object fills the DX frame at a given magnification, you would need the object to be 1.5 times larger to fill the 35mm/FX frame at the same magnification. Conversely, if an object exactly fills the 35mm/FX frame at a given magnification, you would have to shoot with 0.66 times the magnification and a correspondingly longer working distance for the same object to fill the DX frame.
- In practice, lenses around the 100mm focal length (FX body) or 60/70mm (DX body) give a good compromise and are often a good starting point.

Q: What is "Working Distance"?

A: This is the distance between the filter ring on the front of the lens and the subject. The minimum focus distances normally quoted for lenses are subject-to-image distances - i.e., the distance from the subject to the film or digital sensor in the back of the camera body. Although the focus distance for a given lens and magnification setting is interesting, the more important number for the macro photographer is the working distance, as this tells you how much "daylight" there is between you and the subject. Short working distances can make it difficult to light the subject effectively, can disturb nervous subjects like butterflies, can make it difficult to shoot more distant objects, and can bring the photographer dangerously close to aggressive or poisonous creatures. Conversely, lenses that offer longer working distances

are harder to hand-hold and can be unwieldy when trying to follow fast moving objects. There are tables on Tony Jeffree's website that give working distance information for most of the currently available macro lenses, and also for some that are only available on the used market. These tables are also kept updated on the Nikonians website.

Q: What is the relationship between focal length and working distance?

A: If we were considering a simple lens (a single lens element), then placing that lens at exactly twice its focal length away from the sensor/film plane would allow it to focus a subject that was 4 times the focal length from the sensor/film plane, and the image would be life-sized (i.e., you would have a reproduction ratio of 1:1). In this case, the working distance is exactly twice the focal length of the lens, because the lens is half way between subject and image. So, for simple lenses, the relationship is straightforward; however, for the real-world complex optics that we use in macro photography, life isn?t that straightforward.

The focal length of the lens quoted by the manufacturer gives you a rough idea of the working distance that the lens will have, and as a broad generalization, as you increase the focal length of the lens the WD will increase also; however, other factors come into play, such as the focusing method that the lens employs, its optical formula, and the physical construction of the lens.

Some lenses focus only by extension (the effective focal length of the lens doesn't change with focusing, and focusing is done by extending the lens away from the camera on a helicoid) while others (for example, internal focus designs) focus by reducing the effective focal length of the lens. As a very broad generalization, lenses that focus by extension tend to win on working distance over lenses that focus by reducing their focal length, but there are as always exceptions to that rule, which is where the fine detail of the optical formulae and the physical packaging of the lens play a part. The 55mm Nikon Micro, for example, focuses by extension, but because of the need to package up the helicoids sensibly, the front element is deeply recessed, so it?s working distance would be about 40mm longer if it was housed in a different mechanical package, which would give it a WD of 100mm at 1:1, comparable to that of the Tamron 90mm macro lens.

For some reason, the new Nikon 85mm f/3.5 macro lens?s optical design and mechanical packaging result in a WD that is more like the ~100mm macro lenses. If you compare the 85mm with one of the poorer performers (WD-wise only!) from the ~100mm range, the 85mm f/3.5 gives a WD of 141mm at 1:1, compared with the Sigma 105mm f/2.8 macro which only manages a WD of 121mm. So if you had chosen the Sigma 105 over the Nikon 85 purely by comparing the focal lengths and assuming that meant a better WD, you would have been sadly mistaken.

Q: How can I tell what the working distance of a lens will be?

A: You can calculate the working distance at the minimum focus distance of a lens if you know (a) the physical length of the lens when at minimum focus, and (b) the distance between the bayonet mount on the camera body and the film or sensor. The latter is 46.5mm for all Nikon camera bodies; the former depends on the lens concerned - if it is an internal

focus (IF) design, then it is the same as the length quoted by the manufacturer (which is always quoted with the lens focused at infinity); if it focuses by extension, i.e., the length of the lens changes as the focusing ring is turned, then it is that length plus whatever the helicoids have added to the length of the lens to bring it to minimum focus distance. So, for example, the Micro Nikkor 60mm AF-D has a minimum focus distance of 219mm, and is 102mm long when focused at its minimum distance, so the WD at 1:1 is 219mm – 102mm - 46.5mm, or near enough 71mm.

Q: What is the relationship between the focal length of a lens and its angle of view?

A: The focal length of a lens, and therefore its angle of view, determines the degree to which the lens will isolate a subject from its background. Shorter focal length lenses have a wider angle of view, and will include more of the background in the shot; longer focal length lenses have a narrower angle of view and include less of the background, tending to isolate the subject more from the background.

The fact that some lenses focus by reducing their effective focal length can, however, lead to a source of confusion; as the effective focal length of the lens reduces, so the angle of view of the lens increases. So, while the focal length of the lens quoted by the manufacturer (which is the focal length when focused at infinity) will give you a rough idea as to the angle of view of the lens at macro distances, you get a much more accurate idea if you look at the effective focal length when the lens is at closest focus. For a lens focused to give life-size reproduction (1:1) at closest focus, the effective focal length of the lens is ¼ of the subject-to-image distance.

At first glance the Nikon 85mm PC-Nikkor and the Nikon 85mm f/3.5 macro lens should give the same angle of view at 1:1; however, when you look at their effective FL at 1:1 the PC Nikkor is still 85mm, because it is a lens that focuses by extension, whereas the 85mm f/3.5 has reduced to around 71mm. A more extreme example; the Sigma 150mm macro, which is an internal focus design, will give you the angle of view at 1:1 of a 95mm lens, whereas the Nikon 105mm AI, which focuses by extension, will give you the angle of view at 1:1 of a 105mm lens.

Q: Do I need a tripod for macro photography?

A: There is no hard-and-fast rule here. Some macro photographers always use a tripod, others always hand-hold, some do a bit of each. Longer lenses (150mm and longer) are certainly more difficult to manage without a tripod; however, good results can still be obtained with long lenses if good hand-holding technique is used and if additional illumination (flash, studio lights, etc.) is used to allow the use of faster shutter speeds.

Q: Is VR of any use in macro photography?

A: Yes and no. Nikon suggest in their literature that the effectiveness of the VR function on the Nikon 105mm VR macro lens gradually decreases as the magnification increases past 1/30x. Thom Hogan's review of the lens (http://www.bythom.com/105AFSlens.htm) suggests that if you focus beyond 0.7 metres then the VR will provide a useful improvement, although not the 4 stops claimed in the Nikon literature for more distant work. However, as many

purchasers of macro lenses also deploy them for other types of photography as a short telephoto, the VR function on a macro lens may well be useful even if its use in macro work is limited.

Q: Is AF of any use in macro photography?

A: No. In macro photography, the small depth of focus means that accurate focusing is more critical, and leaving the choice of exactly where to put the plane of focus to the camera's AF software won't necessarily produce the result that the photographer is looking for. Most macro work is therefore done with the AF switched off.

Q: Why is it that I can't get the whole of my subject in focus?

A: At the high magnifications that are used in macro work, the depth of field can be very small. For example, a macro lens operating at 1:1 with an aperture of f/16 will give a depth of focus of about 4mm either side of the plane of sharp focus. Open the lens up to f/2.8 and the depth of focus reduces to about 0.7mm either side of the plane of focus. Consequently, the photographer has to take much more care over the choice of where to place the plane of focus, and over the framing of the subject relative to its surroundings and background. For example, you might choose to shoot a butterfly with the axis of the lens perpendicular to its wing, so that the whole of the wing is in sharp focus. Alternatively, you might choose to make use of the shallow depth of focus to deliberately throw part of the subject or its background out of focus.

Generally, when shooting subjects that have eyes, it is a good idea to make sure that the eyes are in sharp focus, as that is where the eye of the viewer is naturally drawn.

See also "focus stacking" below.

Q: What is focus stacking?

A: Recent techniques made possible by digital processing allow the depth of field problem in macro work to be overcome to some extent, but this only works where the subject is static and the camera can be moved in a controlled way, for example on a focussing stage. What you do is take a series of photographs, without changing the focus adjustment of the lens, but moving the camera away from or towards the subject to take a series of pictures that give sharp focus "slices" through the whole of the subject. For example, if you were shooting a bug with a body 2 cms long, then you might set the camera up on a tripod and focusing stage, focusing initially on the very nearest part of the bug (the tips of its antennae, for example), for the first shot. You then advance the camera towards the bug bt 2mm (or a distance comparable to the depth of focus at that setting) for the next shot, advance again, shoot, ...etc. Ten shots would allow you to cover the whole length of the bug (assuming it was head-on to the camera). You then process the set of images using focus stacking software - Photoshop has introduced the capability in recent versions, and there are other stand-alone solutions too - which selects the sharpest areas from each shot and combines them into a single sharp image. Obviously, if there is any movement of the subject during the process, the result will not be satisfactory.

Q: Would a teleconverter give me a bigger working distance?

A: A teleconverter will give you increased magnification; for example, if you have a lens set for 1:1 (life-size), then mounting it on a 2X teleconverter results in 2:1 (twice life-size) magnification. The working distance that you have at 2:1 will be the same as you had with the lens on its own at 1:1. However, if you set the lens for 1:2 (half life-size), then the overall magnification with the TC added will be 1:1, and the working distance will be what you would expect from the lens on its own at 1:2. So, for the same overall magnification, you get increased working distance when you use a TC.

Q: What are extension tubes and bellows for?

A: Extension tubes and bellows are used to allow a lens to focus closer than it can do with its own focusing mechanism. The extension rings in the Nikon system were originally designed for use with Micro Nikkor lenses that could focus to 1:2 unaided, but needed the addition of an extension tube to get to 1:1. The total extension needed to reach 1:1 is the same as the focal length of the lens, and to get to 1:2 you need an extension equal to half of the focal length of the lens. Hence, in the Nikon system you will find extension tubes of 22.5mm and 52.5mm in length, designed to be used with the 55mm and 105mm focal length Micro Nikkors.

Increasing the extension by adding tubes or bellows to a lens will reduce the effective aperture of the lens. This can have a significant effect – if you take a standard 50mm lens and add enough length of extension tube to give life-sized magnification, the effective F-stop is twice that indicated on the aperture ring of the lens – i.e., you lose 2 stops of light by focusing a 50mm lens down to 1:1 magnification. The effect is less severe for wide angle lenses, and more severe for telephoto lenses – there is an excellent tutorial on various aspects of lens behaviour that provides the detailed explanation here:

http://photo.net/learn/optics/lensTutorial

Q: What effect does a supplementary close-up lens have?

A: Supplementary close-up lenses, sometimes incorrectly referred to as "diopters" (see "What is a Diopter?" below) because the unit of measurement of the power of a lens is the diopter, are simple lenses that look rather like filters, and screw into the filter ring at the front of a lens. The effect of adding one of these supplementary lenses is that it increases the magnification that the main lens can achieve. With the lens focused at infinity, the magnification achievable is the ratio of the focal lengths of the two lenses; for example, if the supplementary lens has a focal length of 50mm (this would be a 20 diopter lens) and the primary lens is 100mm focal length, then the combination will give 2:1 magnification (twice life-size) with the primary lens focused at infinity.

Supplementary lenses therefore have a greater effect on longer focal length lenses than on shorter focal lengths. In the above example, if the primary lens was a 50mm lens, then only life-size magnification would be achievable with the primary lens focused at infinity.

The most commonly available supplementary close-up lenses, such as the Nikon 3T, 4T, 5T, and 6T, and the Canon 250D and 500D, have powers in the 1-4 diopter range. Higher power supplementary close-up lenses can be improvised by reversing a prime lens, such as the Nikon 50mm f/1.8, onto the front of the primary lens. Commercial coupling rings can be obtained that screw into the filter rings of both lenses; alternatively, they can be made by buying the adapter rings for the various square filter systems (Cokin etc.) in suitable sizes and sticking them back-to-back with epoxy resin. Some vignetting can occur when you "stack" a reversed lens on the front of another lens; how much (if any) vignetting will depend on the two lenses concerned. For example, with the Nikon 50mm f/1.8 AF reversed on the front of the Tokina 100mm macro, which gives 2:1 magnification with the Tokina focused at infinity, some vignetting occurs at 2:1 with apertures of f/16 or smaller; the vignetting progressively disappears as the lens is focused at distances closer than infinity (magnification greater than 2:1). Note that the "stacked" supplementary lens (the 50mm lens in this example) should always be set so that its diaphragm is wide open.

Unlike extension tubes, supplementary lenses do not reduce the effective aperture of the lens to which they are attached. However, as you are introducing additional glass/air interfaces into the lens system, there may be some degradation in image quality when using supplementary lenses, particularly so if the cheaper lenses available from independent filter manufacturers are used.

Q: What are reversing rings used for?

A: Lenses that were not specifically designed for macro work, such as the Nikon 50mm f/1.8 "standard" lens, can often give better macro results when they are reversed (i.e., the back of the lens facing the subject). This is because general purpose lenses are not designed to work well at the large extensions (long distance between the sensor and the back of the lens) that are needed for close focusing; their optical formula has been optimised around the assumption that the subject-to-lens distance is always larger than the lens-to-image distance. If you want to focus so close that this relationship reverses, it is better to reverse the lens, and keep the lens working closer to its design assumptions. A reversing ring allows this to be done; it has a bayonet ring on one side, and in the case of a Nikon reversing ring, a 52mm screw thread on the other side. You attach the ring to the front of the lens, like a filter, and then fit the bayonet into the camera body, either directly or via extension tubes if greater magnification is needed. The actual magnification range achievable with the lens reversed will depend on the lens concerned.

Obviously, in this arrangement, all mechanical and electrical connection between the back of the lens and the camera body is lost, so this can only be done successfully with manual exposure, manual focus, and a lens with an aperture ring (i.e., not a "g" lens); consequently, old manual focus lenses can be pressed into useful macro service in this way.

Lens reversing can also be useful with some dedicated macro lenses when you want to work at magnifications greater than 1:1.

Q: What is a "Diopter"?

A: The diopter is a unit of measurement of lens power, and is the mathematical inverse of the focal length of the lens. A one-diopter lens has a focal length of 1000mm; a 2 diopter lens has a focal length of 1000/2 or 500mm, and so on. The term is often mis-used to refer to

supplementary close-up lenses, as the power of these lenses is usually expressed in diopters.

Q: Can extension tubes, teleconverters, and close-up lenses be used in combination?

A: Yes, you can combine all of these approaches in order to achieve a desired magnification. If you use both extension tubes and a teleconverter, it is usual to use the tubes between the lens and the TC rather than between the TC and the camera body.

Q: What magnification will I get with a particular combination of lens, extension tubes, and supplementary close-up lens?

A: Riccardo Polini's web page called "Introduction to Macro Photography" has a wealth of information on these and related issues, and contains formulae that, while only strictly holding true for "simple" (thin, single element) lenses, are nonetheless useful in approximating the effect of adding tubes and diopter lenses to a lens. Bill Claff's Simple Close-up Calculator gives a quick and easy way of calculating approximately what a particular combination will give you. There is also an Excel spreadsheet on Tony Jeffree's website that can be used to calculate the effect of such combinations.

Q: What is there to choose between the different makers of macro lenses?

A: There is a wide choice of auto focus macro lenses that will work with the Nikon system; in addition to the 60mm, 105mm, and 200mm Nikkors there are also lenses made by the big name 3rd party lens manufacturers (Sigma, Tamron, and Tokina). In addition, there are numerous manual focus macro lenses that can still be used with Nikon SLR bodies. The good news is that, without exception, macro lenses are optically excellent. The factors that come into the choice are therefore more about build quality, price, and features than they are about optical quality. At the present time, there are "true" macro lenses available for Nikon cameras that range in focal length from 35mm (the Tokina 35mm ATX Pro-D) to 200mm (the 200mm Nikkor). Some examples of differentiators:

- The Nikon lenses generally tend to be better built than the 3rd party lenses; a possible exception is the current Tokina 35mm and 100mm AF ATX Pro-D lenses, that are very solidly built indeed.
- If all you are using the lens for is macro work, then AF isn't going to be of much use to you, so the excellent MF macro lenses are well worth consideration, as they will do just as good a job optically as the AF lenses.
- If you plan to use the lens for other purposes (portraits, landscape, ...), then AF may well be a feature that is important to you, as would be VR.
- AF-S (or the 3rd party lens equivalent - lenses with inbuilt focus motors) is starting to appear in the latest macro lens offerings (Nikon 60mm and 100mm, Tamron 90mm,...). As with AF in general, this is probably only of interest to those that plan to use the lens for other purposes as well as macro.

- Generally speaking, you will pay more for a Nikkor than for an equivalent 3rd party lens.
- If you have one of the consumer grade Nikon bodies (D40 through D100), then MF lenses are usable only with the metering set to manual (i.e., no metering). This is not insurmountable, as it is possible to use a hand-held meter or the camera's "histogram" function to adjust the exposure, but it is obviously less convenient than having the metering capability of the camera. The pro-grade bodies (D1-D3, D200, D300) can all meter with manual focus lenses, although some of the metering functions will be unavailable. In some cases, it may be possible to have a MF macro lens "chipped" to add the necessary CPU contacts to allow full metering capability on the consumer grade SLR bodies.
- MF macro lenses and the earliest AF macro lenses mostly (but not always) only managed 1:2 magnification unaided; you will need extension tubes or supplementary lenses to get to 1:1. Current AF lens models all manage 1:1 unaided; some discontinued models only managed 1:2.

The Nikonians Resources page contains some useful reviews of both Nikon and 3rd party manufactured macro lenses.

Q: When I focus close, the F-number indicated on my Nikon SLR body increases. Why is this?

A: The effective aperture of most lenses changes as the lens is focused closer (see also "What are extension tubes and bellows for?" above). There are a small number of exceptions to this – for example, the Nikon 70-180 macro lens is designed so that the effective aperture is constant as the lens focus ring is rotated, but this is unusual. For most lenses, this effect is not apparent to the user, because the amount by which the aperture changes is insignificant. However, with most macro lenses, the effect is much more apparent when the lens is focused at close objects. Some macro lenses simply don't report this change in effective aperture to the camera body; others do. To see which kind of lens you have, set the camera to aperture priority metering, focus the lens on infinity, and set the aperture to its maximum (smallest F-number, probably f/2.8 or f/4). If the lens is one that doesn't report the effective aperture, then the F number on the camera display doesn't change as you change focus; however, you will see the shutter speed changing as the effective aperture changes. With lenses that do report effective aperture to the camera, both the F-stop and the shutter speed will be seen to change as the lens is focused. In either case, it isn't a problem, as the metering system will compensate correctly for the change in aperture by setting the right shutter speed; however, if you are working with a lens that doesn't report effective aperture to the camera, you have to bear in mind that what you are seeing on the camera display isn't necessarily the effective aperture at that focus distance. There is a more detailed treatment of the maths behind calculating the effective aperture of a lens in this discussion thread on Nihonians: "Understanding Macro Lens Apertures (Micro-Nikkors)".

Q: I find it very difficult to get sharp images when I am shooting macro. Why is this?

A: There are a number of possible reasons:

When shooting at macro distances, the effects of camera shake on the image are significantly worse than at "normal" distances. So, the usual rule-of-thumb of keeping the shutter speed at 1/(lens focal length) or faster for hand-held shots doesn't apply. What you can get away with hand-held will depend greatly on technique. If you think you have done all you can to improve your hand held technique, then try some of the other approaches.

The effect of movement in the subject is magnified in just the same way as camera/lens movement. If you are shooting in the field, even a light breeze can cause significant movement in a subject. Try shielding the subject from wind if at all possible, or maybe just take lots of shots and discard the ones that have movement blur.

You may be using too slow a shutter speed for the conditions. If increasing the aperture isn't an option, because you want to maximise the limited amount of depth of field available, then it may be desirable to boost the ISO setting on the camera and/or use more illumination (reflectors, fixed lights, flash) in order to increase the shutter speeds you can use.

You may simply be focusing on the wrong part of the subject. Checking whether the subject is in focus, or more importantly, which part of the subject is in focus, is harder when working at high magnifications, and is also far more critical, due to the shallow depth of field. If you are finding this to be a problem then it may be worth considering investing in an eyepiece magnifier that will give you a better chance of obtaining accurate focus.

You may have part of the subject in sharp focus, but the shallow depth of focus may be giving you a less than satisfactory overall image. See "Why is it that I can't get the whole of my subject in focus?" above