Mastering Flight Photography - Ian Wilson PhD(optics)

Avian flight photography is the most challenging branch of bird photography. It is routinely used to capturing striking images of medium to large birds in flight with seabirds, waterbirds, cockatoos and raptors popular subjects. At the 'cutting edge' of this discipline, techniques and equipment are evolving, enabling smaller birds and nocturnal birds to be photographed in flight. However, in this presentation, I only discuss the requirements for success when targeting medium to large birds with a suitable DSLR and using available natural light.

The Challenge

The most challenging situation for the photographer and gear is when a bird is directly approaching the camera. It is not unusual for the bird to be travelling with a speed of 5-10 m/sec (see Fig. 1) and depending upon the lens focal length, field of view, and size of the bird, the optimum range for capturing an image will be 10-30 m. Under these conditions the bird will be in good position for only a few seconds providing just one chance to capture the best view with a quick burst. It helps to have the bird well-separated from the background, such as against the sky or distant terrain, but often this is not possible and we have no alternative but to shoot against a high contrast background like nearby trees or a rippled surface when a bird flies low over water. In this situation the AF system can struggle to lock on to the bird and may focus on the background. Then there is the challenge of the available light; in overcast conditions many AF systems lose speed and accuracy and in poor light they can stop working. Successful avian flight photography also depends upon smooth, accurate tracking of the bird and the best way to do this is by hand-holding the camera. Unfortunately, many people are unable to manage a large, heavy, camera and the alternative, shooting off a tripod or monopod, restricts opportunities. These are the main challenges that must be overcome to successfully capture images of birds in flight.

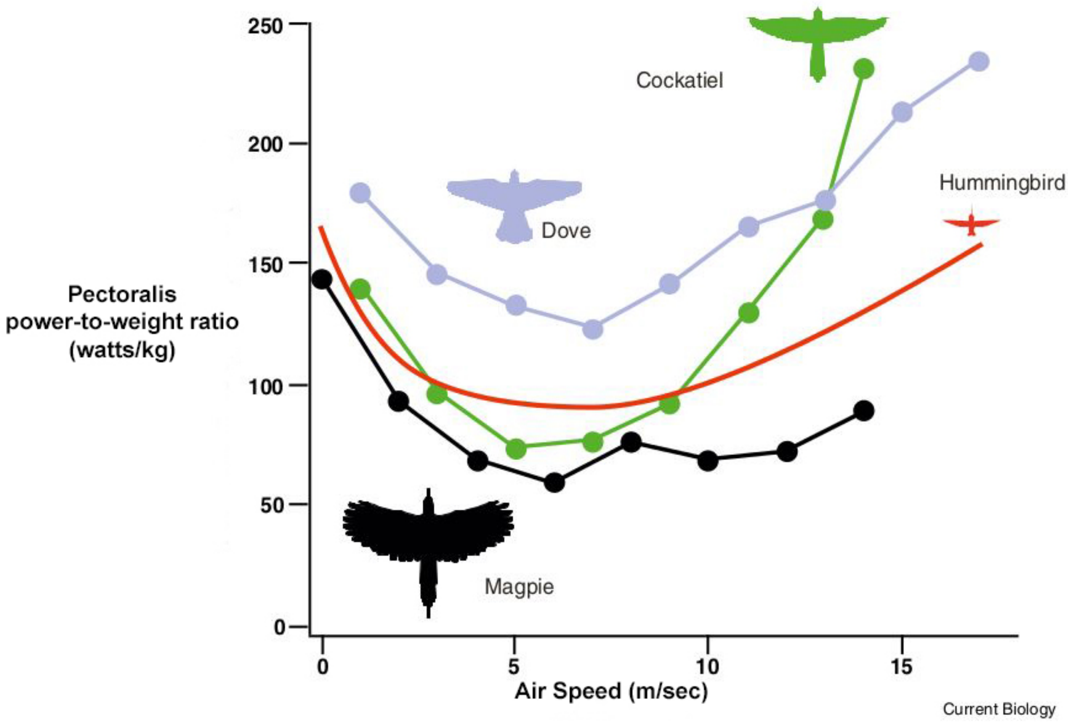

Fig. 1. Air speed of some birds. Cruising speed is at the minimum of the U-shaped power curve. (10 m/s = 36 km/hr)

Basic Camera Settings

The basic camera settings for routine avian flight photography are easily understood. The first is the **aperture setting** required to achieve an appropriate depth of field. This depends upon the focal length and distance to the bird, but this ratio is roughly constant because we use shorter focal length lenses, say 400 mm, for closer birds, and longer lenses, say 800 mm, for more distant birds. This means that we will use roughly the same aperture in both situations. There will of course be a need to make an allowance for the size of the bird but even so, the aperture range required will rarely be outside the range f/5–f/7.1. Novices sometimes think that a large depth of field achieved by closing down the aperture even further is an advantage but this is not generally the case. The aim is to use the minimum depth of field for the focal length, range to the bird and size of bird in order to minimize the ISO sensitivity required for proper exposure.

The second basic setting is the **exposure time**. In principle, an exposure time of say 1/1000 s can be used if one is able to accurately track the bird while the image is captured. Accurate tracking will minimize movement blur due to the forward motion of the bird but if the wings are flapping, they will be blurred. Some wing blur is acceptable and can give the impression of 'action' but generally photographers are unable to track a bird with sufficient precision to use an exposure time of 1/1000 s. The recommended exposure time to 'freeze' the action is 1/2500–1/4000 s depending upon the available light. Exposure times in this range will capture sharp images with good feather detail provided the distance to the bird is in the range 10–30 m.

The final basic setting is the **ISO sensitivity**. This is used to achieve proper exposure once the depth of field (aperture) and exposure time are set. In bright sunlight the ISO required will be about ISO 320 but in overcast conditions it could be over ISO 3200. Best practice is to use the manual (M) mode and set the camera up depending upon the lighting, expected distance to and size of the bird. Use the camera exposure meter to adjust for proper exposure using white or light coloured objects in the environment. You may need to fine tune the ISO depending upon whether you are shooting dark or light coloured birds. Once set, the camera should need no further adjustment unless the ambient light changes during the session. Some cameras provide an Auto ISO option with exposure compensation in M mode but this is not recommended as it can cause significant over- and under-exposure if the metering point drifts off the bird onto the background. Do not use any semi-automatic shooting modes but take full control of your camera using M mode. With some experience you will be able to assess the lighting at a glance and dial in close to the optimum camera exposure parameters without the need to look at the exposure meter. If in doubt, take a test shot of a light coloured object in the environment before you start on the birds.

Typical camera settings in bright sunshine are f/5.6, 1/4000 sec and ISO 320 when using a telephoto lens with focal length in the range 400–840 mm. When there is light cloud cover, or early and late in the day, the light level will be lower and to compensate, increase the exposure time to 1/3200 sec and increase the sensitivity to about ISO 1250. In overcast conditions one needs to further increase the exposure time to 1/2500 sec and adjust the sensitivity for proper exposure. There will be a low light-high ISO limit for your camera that can be determined by experience or by consulting the DxO Labs camera sensor website. The limit is the maximum ISO for good image quality and for the best cameras is about ISO 3200.

If the light is so bad that you need an even higher ISO then you will need to ensure the bird is big in the frame and be prepared to use sophisticated noise reduction to recover the image in post-processing.

Suitable Camera Bodies

In good light there is not much difference between the image quality of the latest full frame and cropped sensor DSLR cameras. However, in low light there is usually a clear advantage for a full frame sensor because its larger pixels produce less noise, have better dynamic range and colour depth. Depending upon the lens focal length, the full frame camera can also have a larger field of view which is handy when trying to find the bird in the viewfinder to initiate tracking.

A good AF system is crucial for successful and consistent results. Unfortunately, there is no industry standard for measuring AF system performance and this is one of the most unsatisfactory aspects of any discussion of these systems. From a technical perspective, the critical success factors for avian flight photography are AF speed and accuracy but there are no test results available to compare cameras. We only have the opinions of camera reviewers, many of whom are compromised by commercial arrangements with camera companies, brand allegiance, and limited technical knowledge. AF speed is a measure of how quickly the camera-lens combination will lock focus on a moving target. There are many factors affecting AF speed including the size of the lens. Large telephoto lenses like the 600 mm f/4 have a physically larger and heavier internal focusing group that must be moved through a longer distance than required in smaller lenses. Focusing requires more power and generally takes a slightly longer time with a big lens. AF accuracy is a measure of the difference between the distance to the target determined by the camera AF system and the actual distance. The distance measurement uses parallax and depends on the separation of conjugate rows of sensors on the AF phase difference sensor chip; the larger the separation (baseline) the more accurate will be the determination of the distance to the target. However, in order to increase the baseline, the phase difference sensor and associated optics needs to be larger and hence require more space in the camera body; this is one of the reasons why Canon and Nikon flagship bodies are so big.

Good AF performance in low light is an advantage but not important if you only shoot in reasonable light. Most cameras suitable for avian flight photography have the centre AF point sensitive down to an exposure value of at least -2 Ev with the latest models sensitive to -4 Ev. With a sensitivity to -4 Ev, the camera is capable of focusing in conditions too dark to track a bird in the viewfinder let alone have enough light for proper exposure. However, AF systems get slower as the light fades so there is an advantage having a sensitive centre AF point. A high frame rate is also an advantage but not essential. It is an advantage because it can provide more frames from which to choose the best wing position or capture other critical moments such as the entry point when a bird dives into water. A frame rate of 5 frames per sec will be satisfactory in many situations; 10 fps is plenty, while higher frame rates are a bonus is some special situations.

Criteria for Good Image Quality

Good image quality can be specified in terms of performance thresholds for signal-to-noise ratio (SNR), dynamic range and colour depth. Each of these parameters decreases with increasing ISO and for acceptable image quality the SNR should remain above 30 decibels (dB), the dynamic range better than 9 Ev and the colour bit depth should be greater than 18 bits. As the ISO value is increased, one or more of these image quality measures will fall below the relevant threshold for good image quality; the ISO at which this happens is defined as the low light-high ISO limit. For the best cameras it is usually greater than about ISO 2400 and means that the camera should be well-suited to capturing birds in flight in overcast conditions and early or late in the day. In the table below we show the low light-high ISO limit measured by DxO Labs for a range of cameras suitable for avian flight photography.

Camera Model	**DxO low light-high ISO limit** ** Cropped Sensor*
Nikon D5	2434
Nikon D4s	3074
Nikon D810	2853
Nikon D750	2956
Nikon D500	1324*
Nikon D7200	1333*
Canon 1DxII	3207
Canon 1Dx	2786
Canon 5DIV	2995
Canon 5Ds	2381
Canon 5DIII	2293
Canon 7DII	1082*
Canon 80D	1135*

Note that Nikon and Canon overstate the ISO displayed on their cameras so that a manufacture's ISO 3200 is equivalent to about ISO 2400 in the table.

The **frame rate** and **low light-high ISO limit** provide a convenient way of identifying the best action cameras suitable for challenging situations. We can show the results on a chart like Fig. 2. Action cameras have a frame rate of at least 10 fps and in poor light the low light-high ISO limit needs to be greater than about ISO 2400. Using these two requirements, the best action cameras are, unsurprisingly, the Canon and Nikon flagships, the 1Dx and 1DxII and D4s and D5, as these cameras have been designed specifically to meet these criteria. That does not mean other cameras are not suitable for avian flight photography; for example, in good light the 7DII and D500 are excellent action cameras, and in low light the 5DIV and D750 are great general purpose cameras capable of capturing outstanding flight shots.

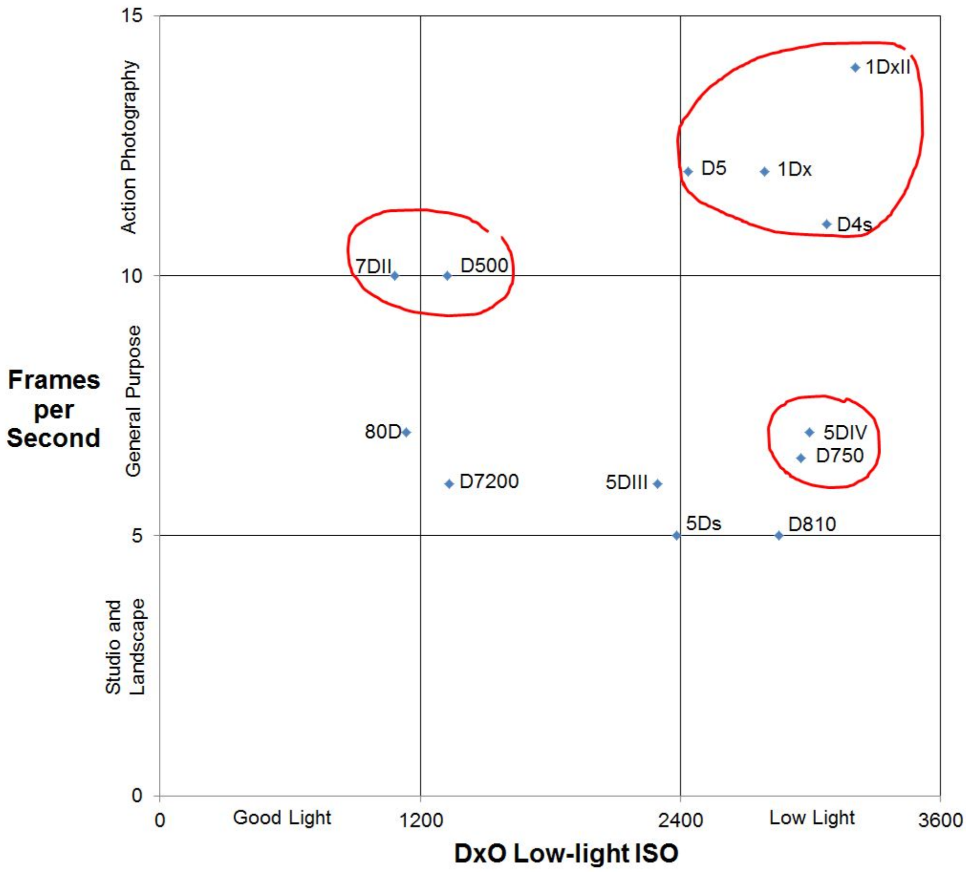

Fig. 2. This chart shows how to identify the best cameras for avian flight photography. For the purpose of illustration only Nikon and Canon cameras are shown.

Suitable Lenses

Fixed focal length telephoto lenses generally have better image quality and faster, more accurate AF than zoom lenses. To compare image quality, refer to the DxO Labs website. AF performance depends on many factors, one of which is the amount of light reaching the AF sensor. The AF is activated when the shutter button is half-pressed and during this time the lens is wide open. It is only during the short time the shutter is actuated that the lens aperture is closed down to the f/No set for the shot. Because fixed focal length lenses (prime lenses) usually have a wider aperture than zooms, there will be more light available for AF and in some cases this permits the use of long baseline diagonal cross-type AF sensors that are more accurate than the usual cross-type sensors. Also, the focus drive motors and encoders in prime lenses are usually better quality and more powerful than the servo motors used in zoom lenses. The result is that primes have a faster, more accurate AF response than zoom lenses. For these reasons, prime lenses are generally preferred for avian flight photography.

Focal length multipliers are a good option for increasing the effective focal length of a prime lens. However, there is usually an adverse impact on image quality and AF response. Some lens-camera combinations perform better than others when a focal length multiplier is used. For example, the Canon 600 mm f/4 II + 1.4x III maintains excellent image quality and the AF response of the latest cameras is little affected by the multiplier. Another combination that works well is the Canon 400 mm DO II + 2x III on a 1Dx body. However, the 2x multipliers are not generally recommended as on some camera bodies they slow the AF system by up to 75% and the image quality can be degraded. Remember that the multiplier changes the effective aperture as well as the focal length. Most of the latest DSLR AF systems will work with an effective aperture of f/8 but the number of active AF points will be reduced, possibly to the centre point only. If the effective aperture is less than f/8 then the AF system will not usually have enough light and will stop working on most cameras.

Image stabilization, otherwise known as vibration reduction, is an advantage especially with long focal length lenses. There are usually two options; vertical plus horizontal axis stabilization (Canon mode 1), and vertical axis only designed for panning (Canon mode 2). The latter is what is required for avian flight photography and can be used for all hand-held bird photography except when the camera body is in portrait orientation.

The birds are usually more than about 10 m from the camera so a **focal range limiter** can be useful to stop the AF system searching for focus closer to the camera. This saves time and helps to quickly acquire focus. It is usually not a big issue as the camera should be pre-focussed beyond the range at which the bird is expected, but without a limiter the camera can be accidently focused close to the minimum focal distance and may not respond in time to get the bird in the viewfinder.

One of the most important questions is: **what is the best focal length for flight photography?** The answer depends almost entirely on the size of the camera sensor pixels. Cameras with small sensor pixels can use shorter focal length lenses than cameras with large pixels. In fact, the relationship is one of simple proportions; if the sensor pixel size is doubled then the focal length also needs to be doubled to maintain the same optical resolution. Acceptable optical resolution is 10 microradian which at a range of 20 m will resolve feather detail as fine as 0.2 mm, the width of a feather barb on a medium size bird. Based on this resolution criterion, the minimum recommended focal length for various Nikon and Canon cameras can be found using the graph shown in Fig. 3. Notice that the Nikon D500 with a 420 mm focal length lens (300 mm + 1.4x) has about the same resolution as a Nikon D750 with 600 mm lens, or a Canon 7DII with a 420 mm lens has about the same resolution as a Canon 1Dx with 700 mm lens (500 mm + 1.4x). Each of these camera-lens combinations, in good light, will resolve about the same amount of feather detail equally well. It is only in low light that the flagship cameras are noticeably better and if a blazing frame rate and the best AF is needed, then these cameras are the only option. Also shown on the graph is a very rough guide to the maximum practical focal length that can be used for flight photography. This is based on results obtained by many photographers and is related to the degree of difficulty of acquiring and tracking a bird in the viewfinder with a small field of view. The field of view gets smaller as the focal length increases and for full frame cameras the longest practical focal length is about 840 mm (600 mm + 1.4x) and for cropped sensor cameras it is about 700 mm (500 mm + 1.4x). While the graph shows the minimum recommended focal length, there can be situations where an even shorter focal length is required, for example, when photographing large pelagic sea-birds at close range.

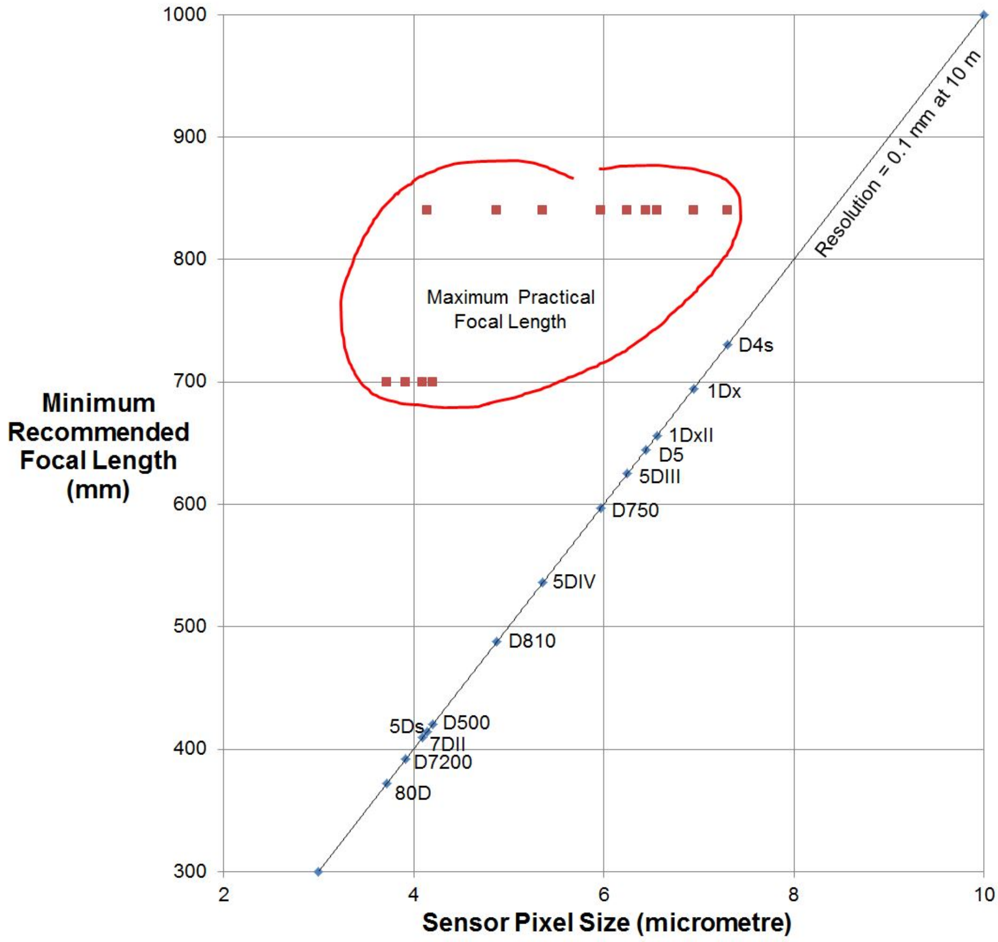

Fig. 3. This graph is a rough guide to the minimum focal length recommended for avian flight photography for some Nikon and Canon cameras.

Camera AF Settings

Finding the best camera AF set-up for avian flight photography can be a daunting task, especially with Canon cameras where there are many different options and combinations of AF parameters from which to choose. There is no universal best set-up because there are differences in AF response depending upon the camera-lens combination, shooting scenarios, and level of skill. Therefore, what I propose to do is to explain the practical effect of the different options and with this knowledge you should be able to find the combination that works best for you and your gear.

The first decision is to select the right **pattern of AF points**. There are three main choices; a few AF points clustered around the centre AF point and covering a narrow field of view, all AF points covering a wide field of view, and an intermediate case with a modest number of AF points. AF covering a wide field of view seems attractive but the wider the field of view, the greater the probability the AF system will lock onto a high contrast background feature. For this reason, wide angle AF coverage is not recommended. On the other hand, it can be difficult to track a bird accurately using a narrow AF field of view and you may stray off the target and lock onto the background anyway. Nevertheless, the centre AF point with four surrounding points, used with the right tracking parameters and in the hands of a skilled flight photographer, is the most accurate configuration (see Fig. 4). Novices and casual flight photographers should use the centre AF point with eight surrounding points; this will be a good compromise that is less demanding on tracking skill and less prone to locking onto the background than wide angle AF coverage. Both Nikon (Group- and Dynamic-area mode) and Canon AF systems offer these options. What may at first seem very difficult will become easier with practice, indeed the best advice I can give to anyone wanting to become proficient is practice, practice, practice.

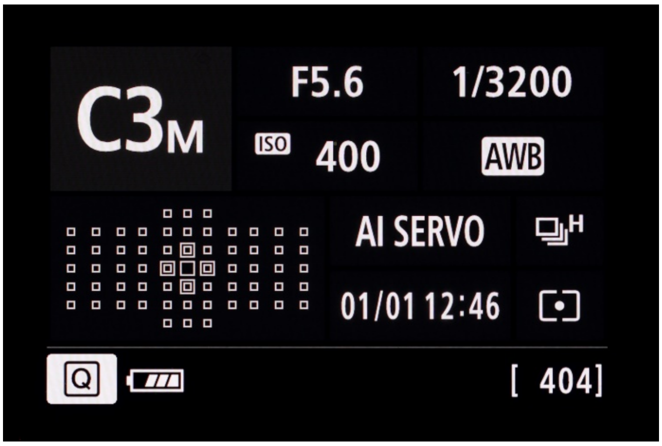

Fig. 4. Typical camera set-up for avian flight photography. Manual, spot metering, AI Servo AF with 4-pt expansion and high-speed continuous shooting.

For Nikon cameras the **AF configuration** needed for avian flight photography is called AF-C and for Canon cameras it is known as AI Servo. The AI refers to Artificial Intelligence and Servo alludes to the fact that a feedback (servo) system is used. AI Servo AF tracking parameters are perhaps the most vexing issue for Canon shooters. There are a lot of combinations and one needs to be a skilled flight photographer to notice much difference. The more advanced Canon cameras try to be helpful by providing pre-sets for six use cases optimized for various sports but none of these are ideal for flight photography. Nikon describe the AF settings for similar use cases in their technical support material for the D5 and D500 cameras.

The first tracking parameter is '**tracking sensitivity**' (Nikon '**blocked focus**' response). This is the time it takes for the system to respond to a change of AF signal and can be a very short time (+2) or a relatively longer time (–2). In flight photography, the most important kind of response is when the active AF point momentarily drifts off the bird onto the background; we want the AF system to be slow to respond giving longer time for the photographer to get the AF point back on the bird. If the tracking sensitivity is set too high then there is a danger the AF system will quickly decide to respond to the change and jump to focus on the background. There is also a disadvantage having the tracking sensitivity set too low; if the AF system does happen to lock onto the background, it will take longer for it to switch back to the bird once accurate tracking is resumed. If this happens one will usually miss the best of the action. Despite this, skilled flight photographers who accurately track the bird prefer to use a setting with a longer response time such as tracking sensitivity –2 or –1 (Nikon delayed response 4 or 5). When a bird is flying directly towards the camera at close range the magnification of the image increases very quickly and it is usually necessary to smarten up the response by increasing the tracking sensitivity to +1 or even +2 (Nikon delayed response 1 or 2).

The next tracking parameter is '**acceleration/deceleration**'. This parameter controls the strength of the response applied when the AF system detects that the distance to the bird has changed. If the response is too strong the focus could overshoot the position of the bird and the AF system will then try to correct itself and may become unstable. When this happens, alternate frames in a burst may be out of focus. If the response is not strong enough the AF may struggle to keep up with the bird. You will also find when using big lenses and/or focal length multipliers, the amount of power required will be greater than with smaller telephotos or the bare prime lens. It will therefore be necessary to fine tune this parameter to suit your gear. A good place to start is with the neutral position (0) and pay particular attention to the results achieved when a bird is approaching the camera. If you find the plane of best focus is consistently behind the bird or on its tail, then increase the accel/decel to +1. If you are using a big lens with focal length multiplier on a 5D- or 7D-series camera, you will usually need to increase the accel/decel to +1 or even +2. The 1Dx cameras are capable of delivering more power to the AF drive and accel/decel of 0 is usually satisfactory but with a multiplier you will probably need +1.

The final tracking parameter is '**AF point auto switching**'. This parameter determines how readily the centre AF point will switch to another point if it drifts off the bird. At first glance it would seem that it should be an advantage to allow the AF point to freely switch to neighbouring AF points as the bird moves around within the field of view of the AF system. However, it is actually an advantage not to allow this because the centre AF point has the largest baseline on the AF sensor chip, and is therefore the most accurate, and it is also the most sensitive in low light. It is therefore an advantage to give priority to tracking using the centre point by delaying switching, thereby giving the photographer more time to get the centre point back on the bird. The minimum sensitivity for AF switching (0) is recommended but photographers having difficulty accurately tracking the bird can increase the switching sensitivity to +1, but remember this will also increase the chance of locking onto the background. This will not be an issue with featureless backgrounds such as blue sky and in this case the switching sensitivity could even be raised to +2.

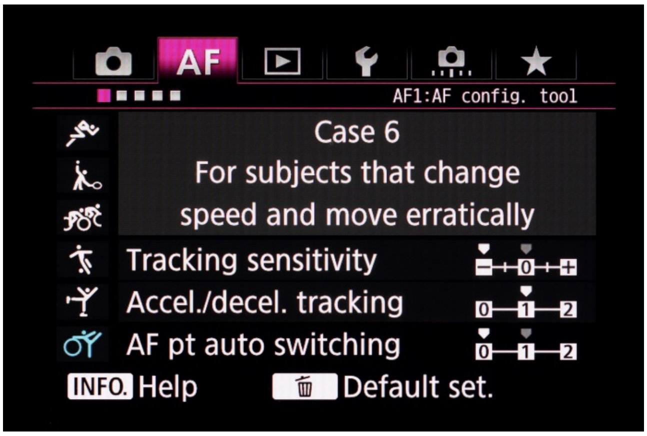

Fig. 5. General purpose set-up for Canon AF tracking parameters.
Tracking sensitivity = –2, Accel./decel. tracking = +1, AF point auto switching = 0.
Fine tune for camera/lens combination, shooting scenario and skill level.

In the Nikon AF system there is no direct equivalent for accel/decel and AF point switching. Instead there is a ‘subject motion’ parameter that can be set to erratic, normal or steady. For tracking birds in flight the normal or erratic setting is recommended.

The latest camera models offer face recognition and a form of **intelligent tracking and recognition** (iTR) based on the colour of the target. Combined with distance information from the phase difference AF sensor, this feature should improve the performance of AF systems. However, for birds in flight, for which iTR was never designed, results are mixed. Photographers have had good results tracking birds against the sky but against complex, high contrast backgrounds it can be confused. Similarly, when tracking birds that have a fast wing beat with light under-sides and dark top-sides, results are unreliable because the target’s colour signature keeps rapidly changing. For iTR to work, it requires at least a nine point zone expansion and we start to run into the kinds of difficulties discussed earlier when the spread of AF points covers a wider field of view. So far, iTR has been of limited value and has not found acceptance amongst the world’s leading avian flight photographers.

The final part of this discussion concerns the **first and second image priority** when firing a burst. The choice is between giving priority to having the bird in focus before the first image is captured or relaxing this condition and giving priority to getting the shot even though the image may not be in perfect focus. Most people would attach high importance to having the first image in focus and it is hard to disagree, especially as the focus will be close to the right distance for second and subsequent frames in a burst. However, there is also a reasonable case for arguing that equal priority should be given to achieving focus and getting the first shot away based on the situation where the centre AF point drifts off the bird at the instant the shutter button is pressed. If this happens, the shutter will not fire with focus priority even though the bird is probably still at the right distance to capture a sharp image. In this situation having equal priority will allow the camera to fire and capture the action. The same reasoning can be applied to the priority given to the second frame in a burst; if priority is given to focus and the AF point has drifted off the bird, then the camera will not fire but if equal priority is given to achieving focus and getting the shot away the camera will happily fire a burst and capture the action. In summary, there are no right or wrong choices regarding the first image priority; focus priority or equal priority are both reasonable options. For the second image in a burst, experienced flight photographers choose equal priority between achieving focus and continuing to shoot.

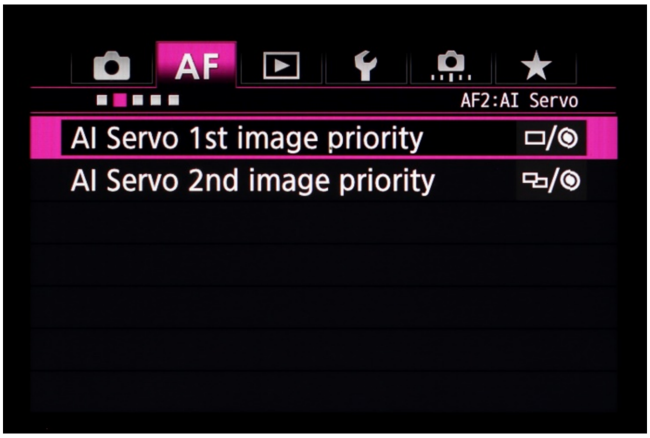

Fig. 6. Set the first and second image priority to the neutral position between shooting and focus priority.

General Advice

The kind of high-speed continuous shooting needed for avian flight photography requires significant processing power to make in-camera image adjustments and transfer the images to a buffer for recording. It is a good idea to try to *minimize the amount of processing overhead to allow the camera to work as fast as possible*. This means turning off any operations that can be performed later in post-processing, such as noise reduction and aberration correction, and use a basic picture style such as ‘standard’ or ‘neutral’. Record only RAW data and not RAW + JPEG as the extra processing required to make a JPEG may slow the camera frame rate. The burst required to capture the peak of the action is usually only 3–5 frames so a large buffer is not essential. What is more important is to *use a fast recording medium* such as a 160 Mb/sec CF card so that the buffer is quickly emptied.

In the field, *study bird behaviour and learn to anticipate when a bird will fly*. Many birds vent before take-off, some birds make a special call or wing-stretch and medium to large birds take off and land into the wind. It is vitally important to quickly acquire the bird in the viewfinder; it takes practice to raise and accurately point the camera, put one’s eye to the viewfinder, and unerringly find the bird in the field of view. If the bird is not in the field of view it is usually necessary to lower the camera to find the bird with the naked eye and then raise the camera again. This takes a few extra seconds and usually results in a missed opportunity. If the bird is about to fly, then pre-focus so that the AF system only needs to make a small adjustment to lock on otherwise pre-focus at a distance so that when one’s eye looks in the viewfinder, the bird will be clearly visible, albeit a little out of focus. If the camera happens to be focused close to the minimum focal distance, then the bird may be so far out of focus that it cannot be discerned and the chance will be missed. Once the bird is visible in the viewfinder use smooth, accurate tracking. Wait for the bird to overfill the viewfinder centre metering circle before locking focus and shooting a short burst to capture the peak of the action. Shoot while the bird is approaching the camera, not after it has passed; images of a bird’s rear end are not very attractive. Eye contact with the bird is highly desirable as it provides a powerful connection between the bird and viewer. Try to shoot at eye level and avoid getting too far under the bird; overhead ventral views have little merit except for bird identification.

Summary

If you have equipment that meets the requirements outlined above, then you will be off to a good start. If in addition you have already mastered the basic skills then you will be well on your way towards making great avian flight pictures. If you are also lucky enough to put yourself in the right place at the right time and have a good ‘eye’, then you have a chance to make outstanding flight pictures. This is the most challenging branch of bird photography and in my experience it needs a great deal of practice to become confident in and to get the best out of one’s gear. Like other branches of bird photography, it requires a lot of luck to capture images of special moments or having stunning aesthetic qualities, what we might call the ‘wow’ factor. My best advice is to ***practice, practice and practice***; eventually everything will fall into place and then the photographer will be free to concentrate on recognising and making the most of opportunities.