Optics for Birding – The Basics

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Christine Reel – WSO Treasurer

Arm yourself with a field guide and a binocular and you are ready to go birding. The binocular – a hand-held, double-barreled telescope – uses lenses and roof or porro prisms to magnify images generally between 6 and 12 times. Some birds are too distant for easy viewing with a binocular. At these times, a spotting scope – a single-barrel telescope with a magnification of generally 15 to 60 power using zoom or interchangeable fixed eyepieces – makes all the difference. Remember that a scope is not a substitute for a binocular, because it must be fitted to a tripod or another stabilizing device, and maneuverability and portability are limited.

Optics shopping

Buying a binocular or scope is a lot like buying a car: do some research, set some minimum standards, and then look at special features and options; also consider a number of choices and compare them. Keep in mind that there is no perfect binocular or scope, only one that is perfect for you. It must fit your hands, your face, your eyes, your size, and the way you bird.

1. **Research.** Plan to visit a local birding site or club meeting and ask a few birders what binoculars or scopes they prefer and why. Then choose a store or nature center that is geared toward birders and has a large selection of optics. Research the various specifications and what they mean to your birding experience (use this sheet as a starting point). Try to read as many impartial reviews as you can. Two websites that contain a lot of helpful information are www.eagleoptics.com and www.optics4birding.com. You can also call Eagle Optics (800-289-1132) for information.

2. **Field test.** Unlike prolonged usage, quick tests in a store or with friends' binoculars in the field do not really tell you what you need to know. You aren't able to tell whether a binocular will cause you too much fatigue at the end of a long birding day, if you can hold 10x binoculars steady enough, or even if you prefer 7x, 8x, or 10x. They also don't tell you whether you prefer a straight or angled scope. (All of these options are explained further on.) Be aware, too, that there is variation in the quality and performance of instruments in the same line, even in binoculars and scopes that retail for over $1,000. If the dealer has more than one instrument in stock, ask to see three instruments and test them all. Pick the one that outperforms the rest.

3. **Cost.** In general, the more you pay, the better the scope or binocular. For example, there are some excellent binoculars available in the $100 range. Move up to $200 to $300 and they can be superb. Near the $1,000 mark you can get eye-popping quality. If you spend a lot of time birding, go for the very best you can afford. If you are more casual with your birding, consider the middle range. For occasional use, a good $100 model will reward you with a good experience.

Binocular basics

1. **Magnification.** The amount of enlargement seen through the **eyepiece**. You locate a bird with the naked eye, and a binocular, by magnifying the image, in effect brings the bird closer, permitting the study of detail that leads to deeper appreciation and surer identification. Most birding binoculars offer a magnification level between seven and ten power. A 7x42 binocular, for example, magnifies objects seven times (we'll get to the meaning of 42 later), and a 10x50 binocular magnifies objects ten times. For general birding, most experts agree that 7x or 8x is best for most birders.

   Many people feel that more magnification helps them see birds better. The problem is that typically the higher the power, the smaller the field of view, the less the depth of field or focus, and the lower the level of brightness. Also, the higher the magnification, the more effect motion – even the normal shake of your hands – has on the image, and the longer you hold the binocular up to your eyes, the more evident shake becomes.

2. **Field of view.** The width of an area seen at 1,000 yards, expressed in degrees of arc or feet; determined by the eyepiece. A minimum of 6.3 degrees of arc or 330 feet at 1,000 yards is preferable for birding. A wide field of view makes it easier to find and track birds when looking through the binocular. The trade-off is in loss of the ability to resolve detail. Other factors being equal, lower magnification means wider field of view; on the other hand, increased eye relief and nearer close focus mean a narrower field of view. Too wide a field of view often results in distortion at the edges of the image.

3. **Depth of field (or depth of focus).** The ability of a binocular to show detail from far to near at a single focus point Shallow depth of field – of about 6 inches or less at 15 feet – causes constant focusing every time a bird moves a few inches toward or away from you. In general, the greater the depth of field, the better the binocular.

4. **Focusing.** The keys to a good-focusing binocular are speed and precision – choose a center-focus binocular that adjusts both barrels at the same time. A good focusing mechanism goes from close focus to infinity within one to two full turns. Most binoculars have a linear focusing gear, and if the gear has a slow gear ratio, it does well in the close range but is difficult to focus at a distance. If the gear ratio is fast, it is difficult to focus in the close range but excels at long distances.

5. **Close focus.** All binoculars can focus at infinity; the real trick in binocular design is in how close it can be focused. A good birding binocular should have a close focus of 10 feet or less, with some models focusing at a mere 3 feet.

6. **Objective lenses.** The largest lenses of the binocular, measured in millimeters. The second number in the 7x42 or 10x50 rating refers to the width of the objective lenses (or aperture). Objective lenses are the light gatherers, and larger lenses let in more light. More light gathering means more detail when the light level drops, and therefore, more quality birding time when the birds are active. A small difference in aperture has a greater impact on the light-gathering ability of a binocular, especially under low-light conditions, than you might expect.

Individual eyepiece adjustment ring (diopter control). This ring or knob, generally a twisting component with plus and minus numbers, corrects for the small differences between your eyes. Here's how to make this adjustment to save yourself from headaches and tired eyes:

1. Close your right eye.
2. Train your binocular at something with fine detail roughly 100 feet away.
3. Move the center focus wheel until the targeted object is sharp through the left barrel.
4. Stop and remove your finger from the center focus wheel.
5. Close your left eye.
6. Open your right eye.
7. Look at the same targeted object and twist the individual eyepiece adjustment ring until the image is sharp through the right barrel.
8. Stop and remove the binocular from your eyes and check the numbers on the individual eyepiece adjustment ring.
9. Repeat adjustment a few times and average the numbers. Be sure to use this setting with this binocular at all times (note that other people may need a different setting).
10. If your individual eyepiece adjustment ring does not lock, you may wish to tape it in place to avoid annoying drift.

Note that these instructions apply to binoculars in which the right barrel is affected by the diopter control; if it adjusts the left barrel of your binocular, reverse these instructions right/left.

7. **Exit pupil.** The size of the image at the focusing point of the binocular. Judge the exit pupil by observing the small circle of light in the eyepiece when you hold the binocular at arm's length. A larger exit pupil means a brighter, sharper and clearer image. It also means that it is easier for your eyes to stay on the image when it is bright out and your pupils are contracted, and that you are able to see the image more clearly in low-light conditions when your pupils are dilated. To determine the exit pupil, divide the width of the objective lens by the magnification. The result should be around five millimeters, but no less than four. An 8x42 binocular has an exit pupil of 5.25 mm.

8. **Eye relief.** The maximum distance your eyes can be from the oculars (the small lenses at the eyepiece) while allowing you to see the entire field of view. Since eyeglass wearers' eyes are automatically at a greater distance from the oculars, they should choose a binocular with greater eye relief (generally between 16 and 20 mm). Retractable eyecups are also important for people who wear eyeglasses while birding. Some retract by pushing them in, others twist in, and some newer eyecups have click stops for greater adjustability.

9. **Glass coating.** When a thin layer of an anti-reflection coating is applied to a glass surface it reduces light loss, meaning the amount of light that reaches your eye is increased. The more complete and complex the coating scheme, the higher the binocular's light transmittance. If the binocular is rated **fully coated**, one or more surfaces of one or more lenses have been coated with multiple films; some surfaces could be single coated and some not coated at all. In **fully multicoated optics**, all air-to-glass surfaces have received multiple films.

10. **Body (prism) design.** Located between the ocular (eyepiece) and objective lenses, the prisms reverse the upside-down and backward image created by the lenses so the image appears correctly. Birding

Cleaning your binocular. You can see through a lot of dust and water spots without noticing reduced image quality. When you feel you must clean your lenses, be extremely careful that you remove all debris by using a soft brush or compressed air. Or you can blow on the lenses and lick them to be sure even tiny particles that might scratch the lenses are removed. Then wipe the lenses with a microfiber lens cleaning cloth or a clean cotton cloth or protected area of your T-shirt. The point is to be gentle – don't damage those expensive coatings on your lenses.

binoculars come in two configurations: **roof prism**, in which prisms and eyepieces are aligned with objective lenses, and **porro prism**, in which prisms sit at an angle to each other and eyepieces are not aligned with objective lenses.

Porro prism binoculars are less expensive to make than roof prism binoculars. You can get the same optical quality for significantly less money. However, they are heavier and harder to weatherproof. A roof prism binocular of the same optical quality is lighter, with fewer problems. Even though they cost more, they are generally more rugged, and in the long run, more cost effective.

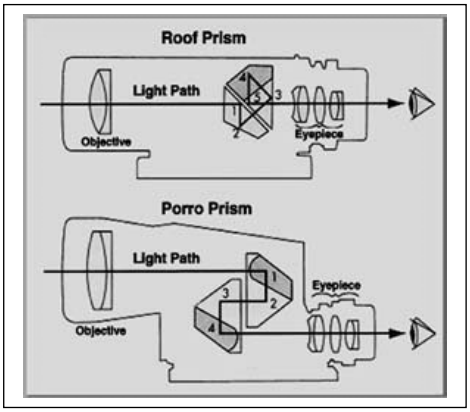

Image from www.eagleoptics.com

11. **Weatherproofing.** Weatherproofing ranges from none to showerproof to waterproof to nitrogen purged. Active birders should get nitrogen-purged waterproofing, whether they live in a humid climate or not, since nitrogen purging can also keep out dust, sand, and anything else that can get inside the binocular, as well as eliminating internal fogging. Along with weatherproofing, consider **armoring**. Usually made of synthetic rubber, armoring protects the body of the binocular from physical harm due to bangs, bumps, and corrosive elements.

12. **Weight.** It takes more force, and therefore more energy, to lift a heavier binocular, hence you feel more fatigued at the end of the day (on the other hand, a heavier binocular resists moving, so it should be easier to hold steady). Think, too, about having the weight of the binocular hang around your neck for a day of birding (or, if you prefer a binocular that feels a bit heavy, consider using a harness instead of a neck strap). Another concern should be balance: a well-balanced binocular puts little stress on your arms, wrists, and hands, while a poorly balanced binocular, even if it is lighter, strains your muscles by forcing them to work against the unnatural torque.

Scope considerations

Spotting scopes are useful for long-distance observations, and they can be of tremendous aid in identifying waterfowl, shorebirds, and raptors. Generally speaking, many of the considerations for choosing binoculars (e.g., exit pupil, field of view, eye relief, weatherproofing) need to be considered when choosing a scope. Some of the binocular requirements are not necessary; depth of field, for example, is not as critical because subjects are much farther away.

1. **Scope design.** Most birders use prism, or refractive, spotting scopes rather than mirror, or catadioptric, scopes. Short and bucket-shaped, mirror scopes provide good resolution at high magnification, but they are not very rugged, weatherproof, or easy to use for birding (they are popular with astronomers). On the other hand, prism scopes are rugged, simple to use and portable, and they provide great image quality.

2. **Body design.** Many scopes are available with **straight-through** and **angled-view eyepiece** designs. Personal preference determines which design is best for you; there is no difference in optical quality. Both designs have their advantages:

   Straight scopes
   - provide a more natural line of sight
   - result in less neck strain during level viewing
   - reduce the likelihood that the eyepiece will collect rain or dust
   - are easier to use for viewing birds on the ground or water or below a cliff
   - are easier to use with window mounts
   - are easier to aim when inexperienced

   Angled scopes
   - are easier to share with a group (can more simply accommodate differing heights of users)
   - have a higher eye point so you can use a shorter, and therefore more stable, tripod
   - are better for birds soaring or in tall trees

3. **Tripods.** A tripod is critical to the operation of your scope. If the tripod is not sturdy enough to keep the scope steady, all the money spent on the scope is a waste.

   Especially when using a straight scope, the most important measurement for stability is the **height** of the tripod with the center column retracted; as you raise the center column, the scope becomes more susceptible to vibration. To calculate the tripod height you need, work down from the top of your head. Your eyes are about 4 to 5 inches below the top of your head. The scope eyepiece is about 4 inches above the bottom of the scope's mount plate, and the tripod head is

about 4 to 4.5 inches high. Adding these up, the height of your tripod without a head should be 12 to 14 inches less than your height. If you are very tall, you may not find a tripod that gives you that much height without raising the center column, so get one that requires as little column rise as possible. If you use an angled scope, your tripod can be shorter – just consider how much you are willing to lean over.

Each tripod also has two critical **weight** specifications. The obvious one is the weight of the tripod, added to the weight of the head and the scope for total weight. (Carbon fiber can save up to 30% in the weight of the legs over the same size of aluminum tripod, but cost can be more than doubled.) The other critical weight is the maximum load capacity. This is an indication of the strength of the tripod, and it should always be larger than the weight of the head plus the weight of the scope.

The **head** should be video style and fluid damped for smooth maneuverability. It should also be rated for the weight of the scope. And it should provide fast and simple attachment of the scope – you don't want to spend valuable time attaching the scope while your bird has a chance to fly.

4. **Magnification.** As in binoculars, the **eyepiece** of a scope determines the magnification. Scope magnification goes from 15x to 75x. While higher magnification is theoretically possible, the resulting exit pupil would limit successful use to only the brightest lighting situations. Also, very high magnification increases the likelihood of distortion from heat waves and scope movement, since these effects are magnified along with the image.

   Unlike the power of your binocular, the power of most scopes can be changed by swapping eyepieces. But changing eyepieces in the field is problematic at best and a disaster at worst. Advances in zoom lens technology over recent years have taken the zoom eyepiece from the lens to be avoided to the one most favored by birders. Zoom eyepieces allow you to scan at low power, then crank up the magnification to get the most detail.

   If you opt for true interchangeable eyepieces, you will want a 20x (or so) wide-field and at least one high power (60x). Anything over 60x is going to be useful only under ideal seeing conditions, which are hard to come by in the field. Wide-angle eyepieces, such as 30x and 50x, are favored by sea watchers and hawk watchers. A 27x eyepiece with long eye relief can be a boon to eyeglass wearers and digiscopers (people who take pictures of birds with their scope and digital camera).

5. **Objective lens.** Generally ranging from 50 to 80 mm in diameter, the objective lens of the scope determines the amount of light that enters the scope. Scopes with an objective lens about 60 mm work well at most times of the day for moderate (15x to 45x) magnification. They are lightweight and suitable for hiking and backpacking. Larger scopes (70 to 85 mm) provide a higher degree of image detail and clarity, but they also have greater size and weight. In general, get the largest objective you are willing to carry.

   The best scopes have objective lenses with **special glass** that corrects certain optical problems. Labeled Extra-low Dispersion (ED), Fluorite (FL), and High Density (HD), this glass makes it possible for all the wavelengths of light to focus at or very near the same point, increasing apparent resolution and color discrimination by eliminating out-of-focus color from the image. This special glass has an immense effect on sharpness, shows better detail on the bird, and reduces eye strain. The actual observed difference between spotting scopes with and without these special glasses is most noticeable under low light conditions and at higher magnifications and longer distances. In scopes that come in both ED/FL/HD and non-ED/FL/HD versions, the better glass adds 50% or more to the cost, but few active birders would say the price isn't worth the improvement in view.

6. **Focusing.** Three focusing mechanisms are used in refractor scopes: single knob, double knob, and helical. Single knob, the most common, tends to be a bit slow but very precise. Double knob consists of two knobs with different drive ratios for the same internal focusing gear; the fast knob allows for quick focusing travel while the slow knob gives precision once you're close to the proper focus. Helical focus, which is good for rapid focus changes, consists of a collar around the scope body to drive the focusing gear. Current developments include variable speed focus.

References:

- Dunne, Pete, Shawneen Finnegan, Kenn Kaufman, Arnold Small, and Peter Stangel. "Birding Binoculars." *WildBird* July 1999: 22–29.
- Finnegan, Shawneen, Peter Stangel, and Pete Dunne. "Optical Delusions." *WildBird* July/August 2002: 44–47.
- Ingraham, Stephen. "Sizing Up Scopes." *Birder's World* February 2004: 31–32.
- Karlson, Kevin T. "Beginners' Guide to Optics." *WildBird* January/February 2004: 28–33.
- www.eagleoptics.com.
- www.optics4birding.com.