Binocular 101

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Looking at birds in the wild just isn't the same without a good binocular slung 'round your neck. A basic understanding of how optics work will put you well on your way to making the most of your birding excursions. But, like the birders who use them, binoculars come in an abundance of shapes and sizes, and prices. So how does a birder pick out the perfect binocular? Is there such thing? A good starting point is to have a solid understanding of how a binocular works, along with the realization that there is no one perfect model. It's all about tradeoffs, and what you choose to gain (and, consequently, sacrifice) is what makes binocular selection such a personal endeavor.

The Anatomy of a Binocular

Let's start by taking a quick tour of your binocular. There are two dominant binocular designs: Porro-prism and roof-prism. Porro-prism binoculars are the "old-fashioned" or traditional type, with a sharp jog in the barrel; roof-prism binoculars can be identified by their two straight barrels. Both styles feature the same basic parts.

- **Prisms.** Whether Porro- or roof-prism, these mirrored pieces of glass inside the housing of the binoculars serve the same function: to correctly orient the image vertically and horizontally.

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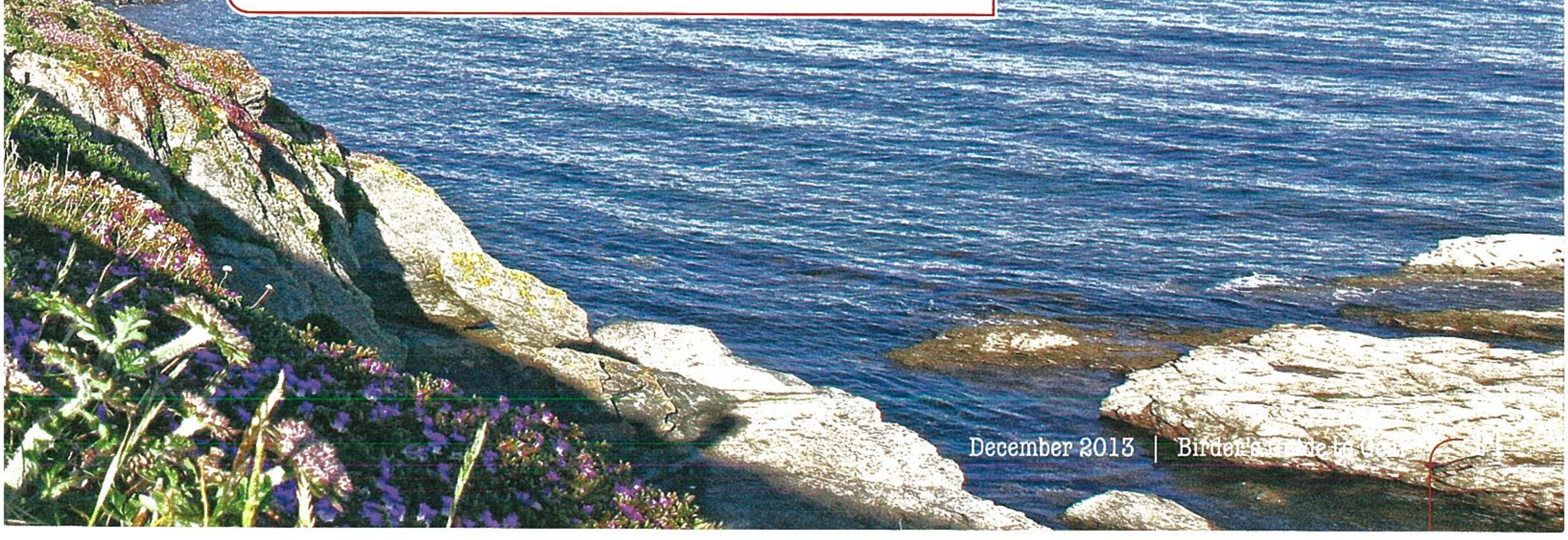


Porro Prism

Roof Prism

Fig. 1 *The roof-prism style of binocular can be distinguished from the classic Porro-prism style by its two straight barrels. Image © Eagle Optics.*

- **Objective lenses.** These are the big lenses at the "far end" of the binocular, whose function is to collect light.
- **Ocular lenses.** These are the lenses you put up to your eyes; they magnify the information collected by the objective lenses.
- **Focus wheel.** Turning this wheel focuses both barrels of the binocular in unison. Some binoculars have separate adjustments for each barrel; for birding, I recommend avoiding binoculars with eyepieces that focus individually.
- **Diopter.** This secondary focus mechanism allows you to calibrate one side of the binocular to accommodate differences in focus length between your left and right eyes. Almost always, the diopter will focus the right eye independently from the left. Adjusting the diopter is simple and—provided you don't lend your binocular to someone else, or the diopter doesn't slip—it needs to be readjusted only as your eyes change. Generally, the diopter will be located somewhere on the right side of the binocular, just below the eyecup. Some binoculars have locking diopters built into the center focus mechanism.
- **Eyecups.** The primary function of the eyecups on your binocular is to prevent your eyes from getting too close to the ocular lenses. Eyecups can also help block out lateral light. If you wear eyeglasses when using binoculars, you'll want to be sure that the eyecup is folded back (if it's of a soft rubber design) or twisted down (if it's a mechanical eyecup, which most modern binoculars employ). Why do this? Your eyeglasses will provide a barrier that spaces your pupil farther from the ocular lens, thus negating the need for the eyecup to serve this function. Otherwise, it's like peering into a keyhole.

What the Numbers Mean

Now that we have an understanding of the parts of a binocular, let's look at some essential concepts. When we talk about the size of a binocular, we refer to it in a configuration, such as 8x42, 10x25, 7x50, etc. The first number (which will always be the smaller of the two) refers to the binocular's magnification: how much larger it will present an object to the user

How to Adjust the Diopter on Your Binocular

Find a stationary object to focus on at an intermediate distance, and, while closing the right eye, use the center focus wheel to get a sharp image in the left eye. Once this is done, close the left eye and check the right barrel for image sharpness. If it isn't as clear as the left side, use the diopter to focus the right side so that it matches the left. Once you've done this, both eyes should see a sharp image as you use the center focus wheel to watch birds both near and far. Unless your eyes change or the diopter is moved, you shouldn't have to repeat this exercise.

compared to that same object seen with the naked eye. Magnification can't answer the question, "How far can I see?" (After all, the sun is 93 million miles away and visible with the naked eye.) What it does answer is, "How small of an object can I see at a particular distance?" With binoculars, we might be able to see a freight liner a few miles out from shore, but that doesn't mean we will be able to see a gull at the same distance.

As you increase the magnification of binoculars, you have the advantage of making something farther away appear closer. As magnification increases, the "power" goes up, but as that number increases, it has other consequences that will make the binocular less user-friendly. Any movement of your body will be exaggerated through the optics, causing a bouncier image and resulting in eye fatigue and a reduction of **resolution**. This is why we have to mount spotting scopes (which have higher power) on tripods. The conventional wisdom here is that magnifications beyond 10x become really challenging to hand hold, and any benefit of the added magnification is offset by a "bouncier" image. Another point to note about magnification is that as you increase power, your depth of field becomes shallower. This means that as birds come toward you or move away from you, you will have to change the focus wheel more often to maintain a crisp view of them, whereas you tend to have more distances in focus at the same moment with lower magnifications.

Magnification has practically no impact on a binocular's dimensions or weight. The second number, however, is indicative of the binocular's physical dimensions. The number following the "x" refers to the diameter, measured in millimeters, of the binocular's objective lenses. This is referred to as the binocular's **aperture**. The bigger this number is, the larger and heavier you can expect the binocular to be, and the more light the binocular will be able to collect. We love a bright image but also want lightweight binoculars; as with many other aspects of binocular design, it's all about tradeoffs.

Fig. 2. *The parts of your binocular that you should know. Image © Eagle Optics.*

Binoculars are often lumped into three general size categories: compact, mid-sized, and full-sized. The term "compact" refers to binoculars with objective lenses smaller than 30mm, "mid-sized" binoculars are those with 30–35mm objectives, and "full-sized" binoculars start at about 40mm and go up to 50mm.

A Useful Equation

I'm not a big believer in throwing out a lot of numbers to illustrate a technical point, but a binocular's **exit pupil** is a great concept to be familiar with. Understanding this concept will allow you to see how magnification and objective lens size work together to impact your experience using a binocular.

The exit pupil is the diameter of the shaft of light (measured in millimeters) exiting the ocular lens. The larger a binocular's exit pupil, the brighter your image will be. Here is a simple equation that will tell you how to determine the size of a binocular's exit pupil:

$$\text{exit pupil} = \frac{\text{objective lens diameter}}{\text{magnification}}$$

All 8x42 binoculars have an exit pupil of 5.25 mm (42/8 = 5.25). When we take a look at a 10x binocular with that same objective lens size, you can see that the exit pupil shrinks to 4.2 mm (42/10 = 4.2), providing less light to the viewer; this is especially noticeable in low-light situations, when our pupils are more dilated. During a bright afternoon when our pupils are generally dilated to 2–3mm, the difference between 4mm and 5mm exit pupils is inconsequential. It's a different story at dawn and dusk, however, when wildlife tends to be more active. For birding purposes, the best binoculars have an exit pupil of at least 4.0 mm.

Understanding the exit pupil isn't the whole story regarding a binocular's brightness. Take any two different makes of 8x42 binocular (remember, both have the same exit pupil: 5.25 mm); it's quite possible that the image you see through one will be brighter than the other. The quality of the glass used in the binoculars and the coatings put on lenses also have an impact on brightness. While two 8x42s will collect the same amount of light, the higher-quality binocular will use that light more efficiently, with more light reaching your eye and less reflected off the glass surfaces to other directions. Price tags usually indicate quality: more expensive binoculars are brighter.

Features and Tradeoffs

With an understanding of the exit pupil, you can see the tradeoff between a compact, lightweight binocular and a larger one that will perform best in low-light conditions. There are some other binocular specifications that are affected by size and design.

A binocular's **field of view** (FOV) is a measurement of how far a user will be able to see, from left to right, when looking through the binocular. A wide FOV is always useful, as it makes it easier for us to scan flocks of birds, to draw size and shape comparisons, and to follow fast-moving birds in flight or through the canopy. FOV is often measured as X feet at 1,000 yards. X is the number of feet an observer can see, from left to right, at a distance of 1,000 yards. Another way to measure this is in degrees. You can convert degrees to feet at 1,000 yards by multiplying the degrees by 52.36.

This may seem counterintuitive, but a larger objective lens does not mean a binocular will necessarily have a wider field of view. In fact, as a binocular's objectives lenses get bigger, the barrels often get longer, which tends to decrease a binocular's FOV. The specification which will have the greatest impact on FOV is magnification. In general, the lower the power, the wider the field of view.

When comparing roof-prism to Porro-prism models, one tradeoff to be aware of is that Porros will often have a wider FOV. This is because the two objective lenses of the binocular are farther apart. Unlike the measurement for exit pupil, FOV varies from one make and model to the next. Not all 8x42s have the same FOV.

Although all binoculars can focus on the distant horizon and the moon, there are limitations as to how *closely* they can focus. In general, a binocular's close focus won't be affected only by its power, though models with a larger objective lens (and thus a longer barrel) often have a reduced ability to focus closely. When comparing Porro- to roof-prism models, that same feature which helps Porros get a wider FOV—widely spaced objectives—hinders their ability to focus closely. The more closely set barrels of a roof-prism binocular make this an ideal design for close focusing.

Fig. 3. The size of the exit pupil determines the amount of light the binocular can deliver to your eyes. Image © Eagle Optics.

Eye Relief

Particularly for the eyeglasses wearer, it's important to note a binocular's stated eye relief. Eye relief is the optimal distance (measured in millimeters) that the ocular lens should be held from the surface of the eye (Fig. 4). Imagine a movie projector displaying an image on a screen. If the ocular lens is that projector and your eyeball is the movie screen, then the optimal distance from the projector to the screen is the eye relief.

The optimal distance from lens to eye is a fixed figure on a given set of binoculars, regardless of whether you have the eyecups twisted down or fully extended. This is important to consider for glasses wearers because glasses limit the ocular lenses' ability to get close to your pupils. Simply stated, most eyeglass wearers get a more comfortable view from bin-

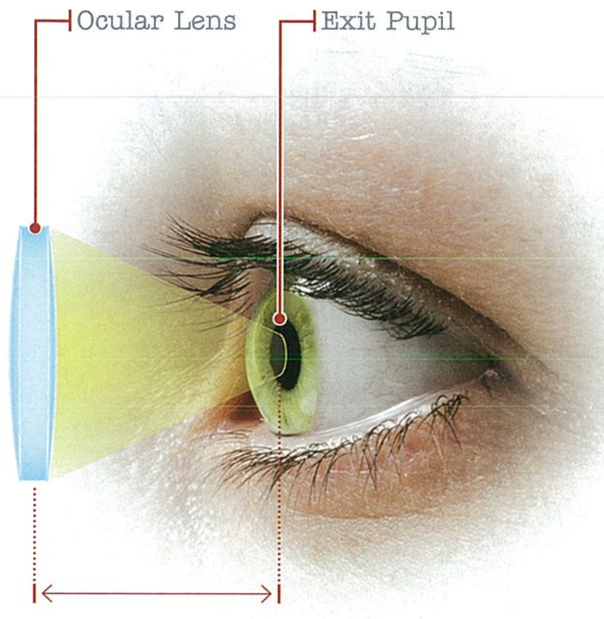


***Fig. 4**. Eye relief is the distance the ocular lens should be spaced from the surface of your eye. Image © Eagle Optics.*

oculars offering 15mm of eye relief or greater. If your eyes are particularly deep set or if your glasses sit toward the front of the bridge of your nose, you may see better with 18mm of eye relief. This figure generally doesn't exceed 20mm, and, like close focus, it will vary from model to model. In general, compact binoculars often have less eye relief than full- or mid-sized binoculars. Fortunately for the birder who wears glasses, most full- and mid-sized binocular choices on the market today offer ample eye relief, and this specification generally isn't a limiting factor in finding a good binocular.

Having the right binocular in your hand isn't necessarily the result of finding the "perfect" one. I'm convinced that perfection doesn't exist. With an understanding of how binoculars function, you can begin to see the game of give and take when opting to enhance one feature at the expense of another. Some birders approach this dilemma by having multiple binoculars at their disposal and choosing the one to best suit a particular outing. Others choose a binocular for all their birding needs after prioritizing features and realize that it will be the best in most, but not all, situations. While the perfect binocular might not be a reality, a working knowledge of how a binocular's size, style, and features can impact your experience in the field goes a long way in helping you find the binocular that's best for you.

Editor's note: For more information on understanding optics, from in-depth articles to videos, visit the educational section of the Eagle Optics website: <tinyurl.com/EO-tech-guide> This topic is also discussed in Rick Wright's book review on p. 46.

Glossary

Aperture. The diameter of the objective lens, measured in millimeters.

Close focus. The shortest distance at which a binocular can focus. If, in viewing things like butterflies, you need to be close to the subject, choose a binocular with a low close focus number, ideally six feet or less.

Depth of field. This refers to what you actually see in focus at any one time. It is the area in focus between the foreground and background of the viewing area.

Diopter. A focus mechanism on all center-focus binoculars to allow adjustment of one eyepiece separately from the other. This is done to compensate for differences between left and right eyes.

Exit pupil. The point at which all of the light rays that entered the objective lens and passed through the binocular exit through the eyepiece to form a magnified, circular image. If you hold the binocular away from your eyes and look through the ocular lens, you will be able to see the clear circular exit pupil.

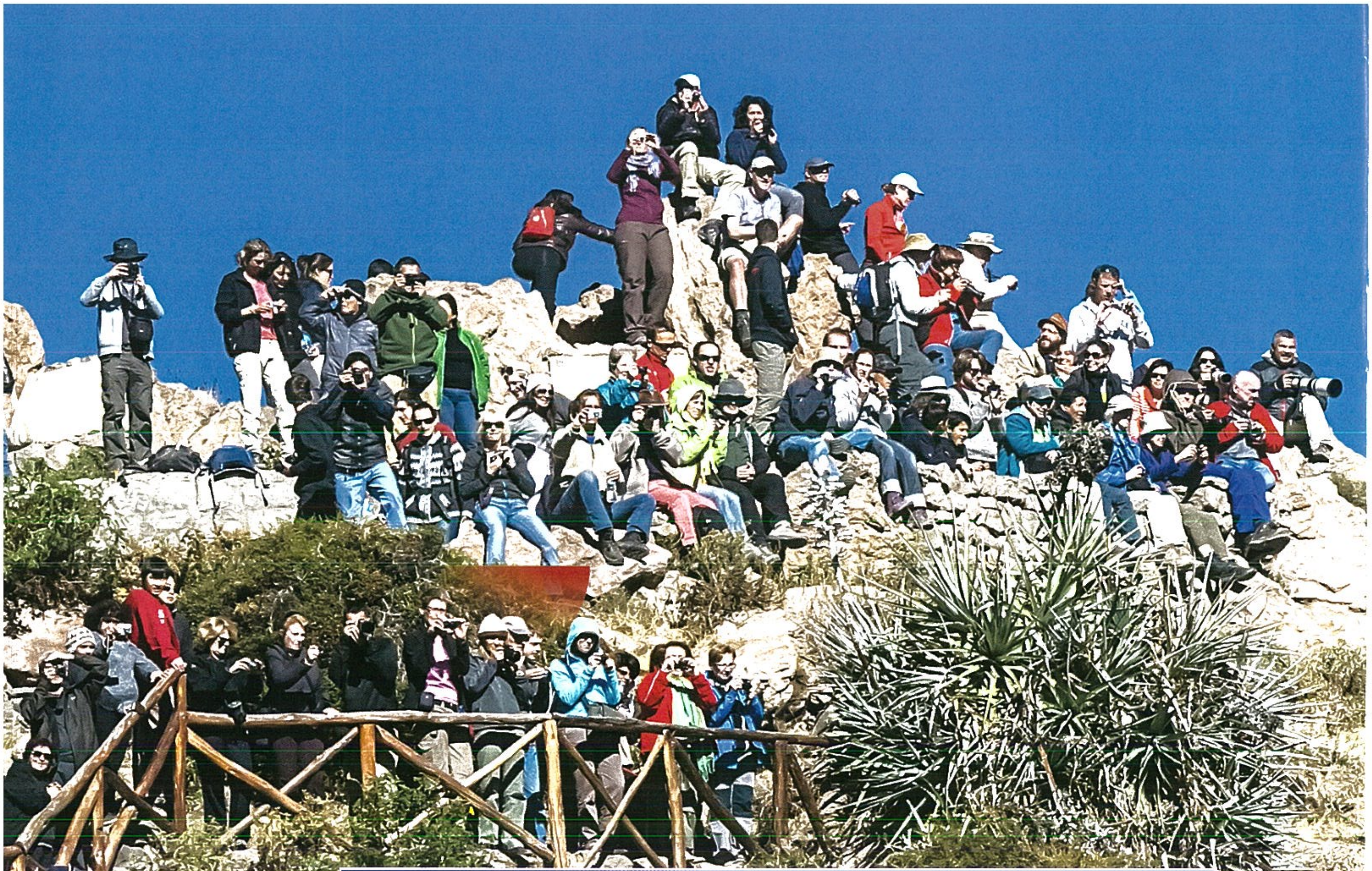
Eye relief. The distance images are projected from the ocular lens to their focal point. The eye relief of a binocular can vary from 5mm to as much as 23mm.

Field of view. The widest dimension of the circular viewing area seen through a binocular. This measurement may be listed on the binocular in either degrees or feet, measured at 1,000 yards. Note: One degree equals 52.36 feet/1,000 yards.

Objective lens. This lens is at the end of the binocular opposite the eyepiece. It gathers light into the binocular.

Ocular lens. The lens in the eyepiece of the binocular that magnifies the image presented by the objective lens.

Prism. A mirrored piece of glass inside the binocular housing which reorients the image projected to the eye so that it is right side up and correctly oriented from left to right.



Birding Photography

Birding and bird photography are, in many ways, incompatible. To truly focus on birding, whether it is seeing more birds or learning more about birds, it is much better to observe and study birds through binoculars than through a viewfinder. Bird photography, on the other hand, takes a much larger amount of patience, requiring the photographer to remain stationary, focusing on "the photo" and often ignoring all of the other birds around. Sure, this is an oversimplification, but practically speaking, the most dedicated bird photographers are lugging around 500-plus-mm lenses, which are not conducive to the mobility usually required for active birding.

Some will debate the merits of this argument, but for sake of conversation, let us assume that most birders are not focusing their time, effort, and money on being stationed behind a massive lens for a host of reasons. Therefore, what I want to talk about is not "bird photography" but "taking pictures while birding", or, as I call it, "bird*ing* photography". That means portability is a serious issue, as are time and financial investments. Few of us are willing to drop $25,000 or more on professional equipment for what amounts to a secondary pursuit.

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