

Advice on Choosing Birding Optics

By Pete Webb, BBC Program Chairman and former BBC President

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Two essential tools for most bird watchers are their binoculars and a good field guide to identify the birds they see with them. After they become serious "Birders", they often leave the field guides at home, but not their binoculars. Instead, the second essential tool will be a spotting telescope for viewing more distant birds, mainly waterfowl and sandpipers, and the occasional rare sparrow perched across a field.

Binoculars - shapes and lenses

Most binoculars come in either of two shapes: porro and roof prism binoculars.

Porro prism binoculars



Roof prism binoculars



Porro prism binoculars are the ones with familiar shape with eyepieces offset rather than directly behind the objective lenses. This form is not as durable as roof prism binoculars, nor as easily made waterproof. They often can be easily be knocked out of alignment, causing the user to see double. Handle with care.

But ..

Porro prism binoculars offer the best optical quality for the money, especially for economy models costing less than \$80.

Roof prism binoculars are lighter in weight, more visually pleasing with the straight-through shape, and by their construction design, much more durable. **But it costs more to get good optical quality in roof prism binoculars.** Inherent optical flaws in the roof prisms do need correction, which costs money, and the cheapest models won't have those "fixes".

There is a **third form** of binoculars - **Galilean** type, a pair of simple "Galilean" telescopes. These telescopes have two lenses and no prism - one objective lens, and an ocular (eye piece) lens which is concave, thinner in the center, instead of convex. These are the oldest and simplest working telescope type, which work well at low magnification, but not at higher magnifications such as needed for bird watching. This is what they look like:



Opera glasses are also Galilean telescopes, in miniature. Usually they magnify about 3 or 4x.

The next step up in telescopes after the Galilean type was the "Kepler" style, with convex lenses both for the objective and for the eyepiece. But this arrangement produces an upside-down, inverted image. Astronomers decided this wasn't that important, compared to the improved image the Kepler telescopes produced, but people wanting to use telescopes to look at objects on land preferred to find a way to get the image right-side up. The purpose of the prisms in binoculars is to flip the image, to re-invert the image back to right-side up (or, more accurately, up side up and right side right). This could be done with sets of mirrors, but the air-to-glass surfaces with those multiple mirrors would reflect away and absorb some of the light, letting less light through than prisms do.

Roof prisms don't make better images, but better lenses do.

In good light, a near-by bird with a dark background behind it will look about the same through any decent pair of binoculars.

At 8x or higher magnifications, especially in poor light (in shadow or backlit against a bright, glaring sky) or for tiny details on very distant objects, fancier (and more expensive lenses) produce a sharper, clearer image and give the observer less eye strain in prolonged use. These lenses can be used in either porro or roof prism binoculars.

I define three major optical classes of binoculars and spotting telescopes, which are determined primarily by the types of lenses used. I split the first group by prism type, and the next two by lens glass formula.

- Economy (\$11 - \$250) - 2 + 1
With 2-element objective lens and simple 1-element eyepiece lenses.
I split this group into two sub-groups by the types of prisms used.
In this group, porro prism models are less durable but are optically superior.
Roof prism models are more compact and durable, but are optically inferior.
- Mid-grade (\$80 - \$500 and up to \$700) - 2 + 2
With 2-element lenses throughout, objective and eyepiece lenses.
I split this group with a small sub-group featuring “ED” glass in the lenses.
- Premium grade (\$900 and up) - 3 + 2-plus
With 3-element objective lens and 2-element specially shaped “aspheric” or “field flattener” eyepiece lenses. I split this group, separating out an “Elite” group (\$1,700 - \$2,700) using expensive fluoride formula glass in the lenses, for the very best optics money can buy.

Other factors can also affect image quality, such as lens coatings, mirror coatings (roof prism models), lens glass formula, and prism glass formula. All of these matter, but lens types make the most substantial difference.

What does "7x35" or "8x42" mean?

The number before the "X" is the magnification.

The number after the "X" is the size, in millimeters, of the objective lens.

The more the **magnification**, the larger the image of the bird will be, but the harder it will be to find the bird in the binoculars, and the harder it will be to hold that image steady so you can see the details. Higher magnification will also reveal the optical flaws in the cheaper classes of lenses.

The larger the **objective lens**, the more the binoculars will weigh, but the steadier they probably will be in your hands. The lightest ones, especially the miniatures with 21 to 28 mm objective lens size, are tiny and weigh next to nothing. But they have a problem – they weigh next to nothing, and with minor motions of your hands and fingers, the image will be jumping around, making hard to keep up with what you're looking at and see any details. Especially at higher magnifications. Larger objective lenses will also accommodate your expanded eye pupils for night-time star gazing. However, contrary to popular belief, they won't make the image brighter or sharper in day-time viewing.

Field of View - how much of the world in front of you is in your image. Typically measured as how many feet across you can see at a distance of 1,000 yards. This can be very important - you see a bird in a tree, bring up the binoculars and focus, and you see an image of leaves, twigs and branches...

But **which** leaves, twigs, and branches?

Which **tree**?

Where is your **bird**?

It took me years to gain the skill to reliably find my bird, using 7x35 binoculars with a wide field-of-view. Binoculars with a narrower field, as is to be expected at higher magnifications, make your bird much harder to find.

For beginners, casual users and visitors, it's best to stay with 7x35 binoculars.

Experienced birders wanting more magnification, and skilled enough to use it, and also willing to spend over \$80, should consider one of the sealed waterproof roof prism models, with mid-grade or premium-grade lenses, usually 8x32 and 10x32 "mid-sized" or 8x42 and 10x42 "full sized" models.

To test these parameters for yourself, and find the best combination of weight and magnification for your own use, you can start by attending some of the more popular bird club field trips, and try out other peoples' binoculars, comparing them with your own. Pay attention to the magnification and objective lens size (weight) while comparing. This test is mainly for finding what configuration works best for fighting the jumpy image, finding your bird, and to a lesser extent with how well you can see details on distant objects.

The Book Test

For a better measure of how well various models of binocular work for you in seeing small, distant details - If you can, get a good assortment of binoculars to try out, set up a book, or other object with fine print, about 15-20 feet away. View the book with the binoculars and see just how far away you can put the book and still be able to read the text. No fair putting the binoculars on a non-moving surface to steady them; you won't be doing that in the field bird watching. This is to test what you can actually see in various kinds of lighting with various kinds of binoculars with different objective lens sizes, different magnifications, and different lens types, to see how well you can make out distant small details. To make the test even better, try it with difficult lighting - put the book in deep shadow or try to read it backlit against the glare of a bright sky. This should give you an idea of what configuration actually works best for you in making out fine details at a distance.

I tried this at home one day, comparing 8x42 and 10x42 roof prism binoculars, including one 8x42 model with a brighter image due to a brighter, silver mirror coating in the prisms. With that model, I could actually read fine print on a book about 15 feet away slightly better than I could with my standard 10x model (with HR aluminum mirror coatings). I believe some of that may have been due to the greater amount of jumping around of the image in the 10x model, and partly due to the brighter image. But I wasn't expecting to actually see more with the 8x binoculars.

Be that as it may, I do remain "addicted" to the slightly larger image of my 10x binoculars, even if I no longer feel certain I'm actually seeing any additional details in my viewing.

I have also similarly compared "standard" glass and "ED" glass binoculars, and found that the ED glass did allow me to more easily read text on a book, especially when comparing the two binoculars on the text in more difficult light. (Both binoculars are 10x42 models which I own.)

At a presentation with the Baltimore Bird Club in September 2013, several models of binoculars were on a table for attending people to try out on a book set up about 15-20 feet from the table. These included several economy-grade porro prism binoculars, an economy-grade pair of miniature roof prism binoculars, two mid-grade roof prism binoculars (including mine), and one premium-grade pair of Zeiss roof prism binoculars. Most of the observers felt that my mid-grade model and the Zeiss model stood out as clearly better than the others, although another club member said that to him they all looked about the same, and he preferred his own model primarily for how it felt in his hands. I personally also did notice the clearer image of the letters in the book text, comparing my mid-grade roof prism binoculars with the premium Zeiss binoculars. This test would have been better with a wider variety of different binocular types, including mid-grade porro binoculars, and with some more challenging lighting on the book.

- **So what's out there?** (see more complete listing, with spec's, later this article)

I divide the binoculars on the market into three major classes, with two sub-classes within each larger one. The first major class is split by prism type, the next two are split by glass formula in the lenses.

Again, I define three major optical classes:

- economy (\$11 - \$250) : 2 + 1 , split by prism type,
2-element objective, 1-element eyepiece lenses
- mid-grade (\$11 - \$500) : 2 + 2 , split for ED glass in the lenses,
2-element objective and eyepiece lenses
- premium (\$900 - \$2,700) : 3 + 2+ , split at \$1,700 for FL glass in the lenses
3-element objective, 2-element aspheric/"field flattener" eyepiece lenses

Economy grade - 2 + 1 (\$11 - \$250)

The group I call **economy-grade** binoculars have a 2-element "Achromatic" objective lens and simple 1-element eyepiece lenses.

This group splits to:

- **Economy roof prism binoculars**

At the economy price range, the roof prisms won't have the "fixes" needed to make them optically comparable to porro prisms. Even the very most expensive top-of-the-line roof prism binoculars can't get prism performance quite up to that of porro prisms, but they (with money put into the "fixes") can get darn close.

What about those cheap mini-sized roof prism binoculars?

Some ultra-cheap roof prism binoculars are available with objective lenses about an inch in diameter (21 to 28mm diameter - an inch is 25.4mm). They are very small and easy to stuff in a pocket and weigh and cost next to nothing. But they have a problem - they are tiny and weigh next

to nothing. In your hands they don't hold steady. Larger, heavier binoculars tend to hold steadier in your hands, so the image doesn't jump around as much. This jumpy image is also a problem with higher magnification, even with the larger, heavier binoculars. Another thing to consider - cheap roof prism binoculars won't offer the optical quality of porro prism binoculars. At that price range, they won't have the "fixes" needed to deliver the bright, clear, detailed image of porro prism models. One popular economy model is the Bushnell Powerview 8x21 miniature, \$12 plus shipping, at Amazon.com, March, 2105 price. This model isn't waterproof. Sealed, waterproof models include Tasco Sierra models, TS825D (8x25) \$32 Amazon, and a full-sized 10x42 model for \$44, again Amazon prices not including shipping. The sealed models should be more durable and withstand more abuse than other models which are either porro, or not waterproof, or both. The tiny 8x21 model (10x25 is also available) would serve as a pocket spare, and the full-size 10x42 would be a possible starter for a kid not yet ready to be trusted with a more expensive or fragile model. But all models at 8x or 10x magnification will have a limited field of view, not easy for a beginner to use, to find a bird before it flies away.

- **Economy porro prism binoculars**

Porro prism models costing less than \$80 have brighter, clearer, sharper images than do comparably-priced roof prism models. They will, however, be more bulky, fragile and easily knocked out of alignment; handle these with care. Most models under \$80 won't be waterproof.

Two economy-grade porro 7x35 models are worthy of consideration for casual or beginning users, or for visitors to use, with a wider field of view than most of the more expensive models with higher magnification in this article, making these much easier to use. They are the Bushnell Falcon, about \$24, and the Tasco Essentials Zip, about \$25, March 2015 Amazon.com prices. With shipping, this would come up to about \$30.

Another variation seen in miniatures places the two objectives closer together than the eyepieces. An example worthy of consideration for butterfly watching is the Pentax Papilio, which comes in 6.5x21 and 8.5x21 models. This model has an unusually close focus at about 3 feet; the 7x35 models above get their closest focus about 15-20 feet out. The Papilios cost about \$100 - \$150, and will be more suitable for butterflies and other small, close objects than they will be for bird watching. These miniatures will have the jumpy image problem, more so with the 8.5x model.

Since these are porro models and are not waterproof, handle with care.

To get significantly better than the \$25 porro prism 7x35 binoculars above, requires getting models costing \$80 and up, and I would recommend one of the sealed waterproof roof prism models, usually 8x32, 10x32, 8x42, or 10x42 models, from the higher lens classes below.

Mid-grade class, 2 + 2

2-element objective and eyepiece lenses

The **mid-grade group** gets its improved performance from having 2-element "Achromatic" lenses throughout, and BaK-4 formula glass in the prisms, which let more light come through. Most of these will be sealed, roof prism binoculars. Notable models here include the Eagle Optics Shrike, \$100 - \$110, the Bushnell Natureview roof prism models, \$80 - \$120, and the Atlas Optics Radian, \$130 - \$140, all sold at Eagle Optics, prices as of Mar. 2015. The very best "mid-grade" binoculars,

at about \$300 - \$350, are the Monarch 5 ED models, with special mirrors and with ED glass in the lenses, giving them the brightest image with most intense colors in my "mid-grade" level group (\$80 - \$500), and the Zeiss Terra binoculars, also about \$300 - \$350. Any mid-grade model (with the 2-element lenses) will, at magnifications of 8x or higher, produce a clearer, sharper image than any of the economy-grade binoculars, and even better than some porro prism models (with single-element eyepiece lenses) costing up to \$250.

The difference that improves the image is in the type of lenses, not the type of prisms. The sealed, roof prism models are preferred for their compact and durable construction, putting up with more abuse in the field than the more fragile porro prism models. At this grade, they will have the "fixes" to make the roof prisms perform at a level fairly comparable to, if not quite up to, the more fragile porro prism models.

Image Stabilization

Another interesting option for some is Image-Stabilized models, most notably models by Canon - an 8x25 model for \$380, and a 10x30 model for \$505. For viewers having trouble holding the binoculars steady enough to get a stable image, this option may really help. Canon also offers a more expensive 10x42 model for \$1,300, which is probably in the premium optical class, see below.

- **Intermediate:** \$600 - \$800 – these models are mostly unknown to me; while they still have all 2-element lenses, the prices are higher. Perhaps some have more expensive lens coatings, the more expensive di-electric mirror coating for roof prism models, or even some of the aspheric/"field flattener" eyepiece lenses - ? The Cornell study in fall, 2013 did rate the Monarch 7 model (about \$550) higher than the Monarch 5 ED (about \$350); both have ED glass in the lenses and the di-electric mirror coating. The Nikon literature doesn't say what makes the more expensive Monarch 7 model better.

The Premium Class , 3 – 2-plus , \$900 and up

This class features THREE-element objective lenses, for more uniform focus of the colors, and two-element eyepiece lenses with special "aspheric" / "field flattener" shapes to get sharp focus across the full field of view. This produces a noticeably improved image, clearer and sharper, with even less eye strain in prolonged use. According to the fall 2013 Cornell review, the Zeiss Conquest models, starting at about \$900, offer the best optics for models under \$2,000 in price. If you can afford any one of these premium models and use it for a while, you won't want to settle for anything less.

The next step up is a small one in optical quality, but hikes the price to about \$1,750 to \$2,650, to get the **elite class** with the expensive **fluoride glass** formula in the lenses, for the very best optics money can buy. Elite-class models by **Leica**, **Zeiss**, and **Swarovski** are rated about equal for image quality by the Cornell reviewers, who also questioned whether the small improvement with the fluoride glass makes the extra price worth it. One new innovation, which Cornell reviewers didn't consider important, is a higher-transparency "HT" fluoride glass formula by glass company Schott, affiliated with Zeiss. The formula, when used in the lenses, adds about 2% to the light getting through the binoculars. Leica is now licensing from Schott to use the Schott glass (as they call it) in their newest top-grade Ultravid HD Plus series. Zeiss offers it in their Victory HT series and in their upcoming Victory SF series (not yet shipping as of end of March, 2015).

Caveat

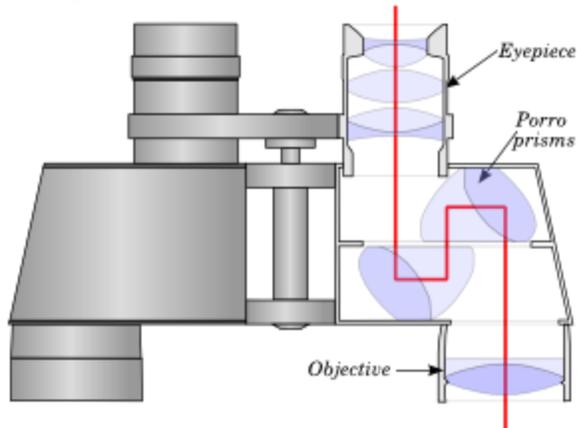
I'm the only one classifying binoculars and/or telescopes into these groups and naming them as I do. The sales literature at manufacturers' and sellers' websites usually don't even mention lens types being used, despite their importance. But optics test scores in the comparison studies by Bird Watchers' Digest, Birders' World, and Cornell do show the differences among these groups.

More nuts and bolts – how things actually work.

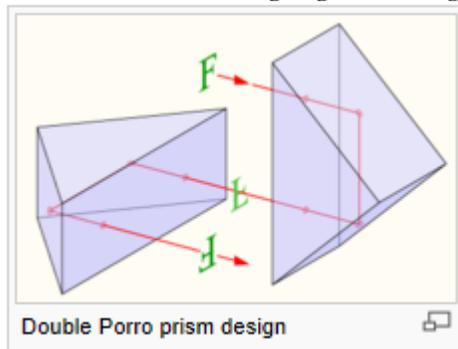
Three forms of prisms are used in binoculars, two of the “roof” type and one of the “porro” form.

Porro prisms were the first, and optically best, to be used for this purpose. They use internal, angled surfaces to act as mirrors (without the multiple air-to-glass interfaces) and reflect the light at angles four times to get the image righted. All internal reflections are 100%, and the only loss of light is in the surfaces of the prisms where light passes through air-to-glass interfaces, and in the glass itself, where, depending on the glass formula, some of the light gets absorbed by the glass itself.

Porro prism binoculars look like:



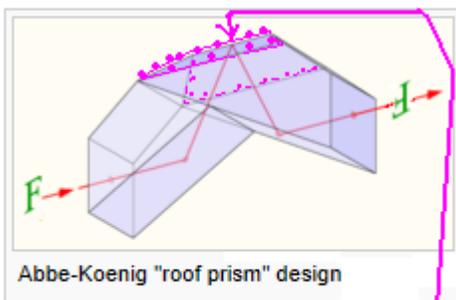
And here's how the light goes through the porro prisms:



Notice that the two Porro prisms shown are oriented 90 degrees apart, so they flip the light both vertically and horizontally.

Roof prisms come in two “flavors” : **Abbe-Koenig** and **Schmidt-Pechan** sets. The Abbe-Koenig prisms tend to be larger and heavier, while the Schmidt-Pechan sets (of two different prisms, the Schmidt prism and the Pechan prism) come out lighter and more compact, and are more popular. The overwhelming majority of roof prism binoculars use the Schmidt-Pechan set. Both roof prism types include a “roof” –shaped surface which gives them their common name, and also a problem – at that unique split reflection surface, the two halves of the light passing through get out of phase with each other, leading to a dimmer image with smudging and lack of fine detail definition. It takes a bit of money to apply a “phase correction coating” to fix this problem, and the cheapest roof-prism binoculars don’t have this “fix”.

Since it’s a bit simpler, we’ll start with the Abbe-Koenig prism, used in a couple of the elite binocular models. Here’s how they’re shaped, and the path by which light goes through them:

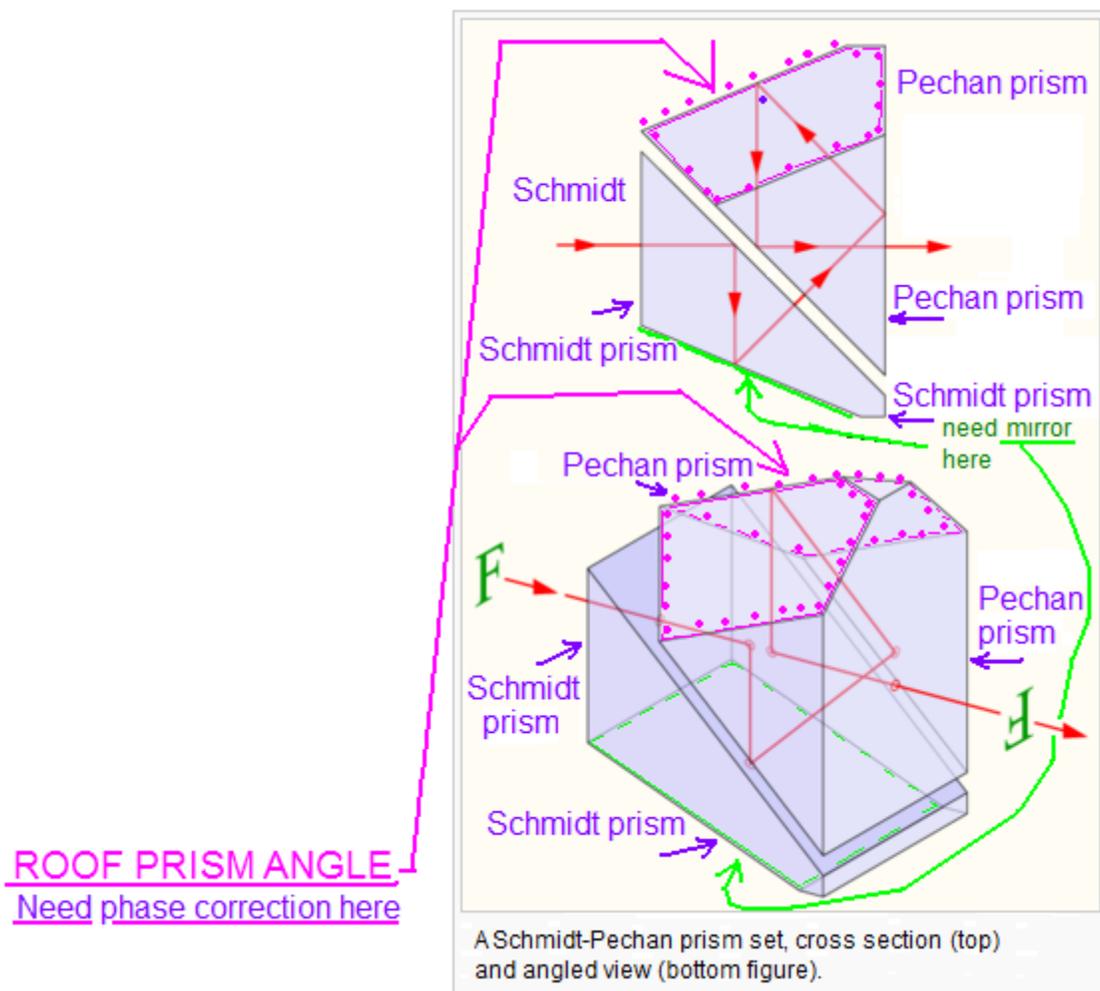


ROOF PRISM ANGLE.
Need phase correction here

This illustration shows the “roof” surface on the top. That’s where the phase- correction coating needs to be added to fix the phase problem. As with the porro prisms, all internal reflections are 100%. Light loss is in light absorbed by the glass, and at the air-to-glass interfaces the light has to pass through. With proper phase correction, these will perform much like porro prisms.

Schmidt-Pechan prisms are a bit more complex. Two unequal prisms are used, with the Schmidt prism used primarily to “feed” light into the complex Pechan prism at a certain angle to make it work. But in doing this, the Schmidt prism has to get light reflected at an angle where it would normally just pass through the glass-air interface and out of the prism instead of reflecting. A reflective mirror coating is needed at this surface to keep the light going along the proper path. A phase-correction coating is also needed at the “roof” surface on the Pechan prism (on “top” in the illustration below), to get a clear image. The cheaper roof prism models won’t have the phase coating.

The Schmidt prism, bottom in the illustration below, receives the light, which goes through one normal, internal, 100% reflection, then another at an angle requiring the mirror coating, going up into the Pechan prism, above the Schmidt prism in this illustration. After one internal reflection, it goes up to the top of the Pechan prism where the “roof” surface is, goes through that reflection needing the phase-correction coating, through another internal reflection, and out through the same surface that two steps back had reflected the light up to the “roof”. This is possible due to the angle at which the light is traveling in relation to the glass surface. As with all prisms, light loss happens with any absorbing the glass does as the light passes through it, at the air-to-glass interfaces the light travels through, a bit at the “roof” surface due to phase cancellation, and now also at the one mirror surface on the “bottom” of the Schmidt prism. See mirror coatings later in this article. The illustration below shows a cross-section of the two prisms, with the light path, and below that an illustration with an angled view, including the light path.



More on the durability of roof prism binoculars vs porro - some years ago, I purchased a sealed, waterproof porro model, Swift Ultra-Lite, but after a month or less of use, the eyepiece mounting broke, rendering the binoculars unusable. So I purchased, as a replacement, the Swift Ultra-Lite roof prism model, a “twin” to the porro model. The roof prism Ultra has proved its worth, surviving the “dog wars” – chewed up by the family dog, but still working just fine. For me, at least, it is now imperative that anything I purchase be rugged & durable, and sealed waterproof against the elements. Before the Swift Ultra’s, I owned a premium-class pair of Zeiss binoculars which, unfortunately, were NOT sealed waterproof, and over about 8 years of use, foreign material got in and ruined the view. They got to where I could hardly see through them at all, like looking through a fog bank. Additionally, the focus mechanism got very stiff and hard to use, and also got out of adjustment, so the diopter adjustment to keep both eyes in focus couldn’t compensate for the large difference in focus between the two sides. I believe salt spray from some pelagic trips I took may have done a large part of the internal damage. However, it must be noted that another bird club member with the exact same Zeiss model still has those same binoculars, and they still work fine, about 35 years after purchase. I’m just not as good at protecting my optics from damage. I also had an expensive, high-quality spotting scope by Questar, which also wasn’t sealed and which also became unusable, again fogged up by encroaching foreign material getting inside and obstructing the view, like looking through thick fog. My current binoculars and my current spotting scope are now both sealed against the elements, and I will no longer buy any that isn’t. Fortunately for klutzes like me, virtually all medium-grade and premium-grade optical products today do come fully sealed, waterproof and fog-proof, and are designed to put up with more abuse than older models were.

Now for some “technical” explanations, and terms and their meanings, mostly for binoculars –

About objective lens size – this determines how much light those objective lenses can “pull in” for the image. Popular belief has it that larger objective lenses make the image clearer and brighter, with more sharply defined details.

The actual truth is a bit more complicated –

Exit Pupil - The objective lens size, divided by the magnification, yields something called the “exit pupil”, which is the actual size of the shaft of light coming out of the eyepiece lenses for your eye to take in. For example, 7x35 binoculars will have 35 millimeters divided by the 7x magnification, producing an exit pupil 5 millimeters wide. Now, in daylight conditions, your eye’s pupil will probably be dilated to about 2 – 3 millimeters. That’s how much your eyes will take in; the remainder of that 5mm shaft of light will bounce off the opaque surface of your pupils and won’t get into your eyes. In fact, in broad daylight, binoculars with an exit pupil of 3mm or more will produce an image every bit as bright and detailed as binoculars with an exit pupil of 5 or 7 mm, popular belief to the contrary. This will hold up even in deep, shaded woods. But at twilight, or even more so at night-time, as your eyes adjust to the darkness, your pupils will dilate wider. A young person’s pupil may dilate as much as 7-8mm, while a middle-aged person’s pupils will probably only dilate to about 5mm. So binoculars (or telescopes) with an exit pupil of 5mm will give your eyes all they can take in, even in the darkness of night, unless your pupils can dilate wider than 5mm.

Some people use 50mm sized objective lens binoculars, but that’s probably heavier than you really need. 10x50 binoculars will produce a 5mm exit pupil, while 10x42 binoculars will have an exit

pupil of 4.2mm. But that's plenty for all but the darkest nights, and doesn't really lose all THAT much even then. The popular 8x42mm size gets an exit pupil of 5.25mm, which is plenty. Even the 10x32 option puts out a 3.2mm exit pupil, which is plenty for day-time use.

At the darker light levels, even an unlimited exit pupil from extra-large objective lenses won't produce a bright enough image to see colors well. If it's too dark to see colors well without binoculars, you won't get more colors looking through them, regardless. I know, I tried.

Coatings

All binoculars, even the cheapest, offer at least some **anti-reflective coatings** on at least some of the lenses to reduce light loss through reflecting when the light should be passing through the lenses and prisms. More expensive binoculars have fancier, more effective multiple layer coatings that let more of the light through. Most mid-price and high-price binoculars boast "FMC" meaning Fully Multi-Coated on all air-to-glass surfaces of lenses and prisms.

Roof prism binoculars also need additional coatings on certain surfaces of their prisms to keep the light going through properly. The "roof" surfaces that give roof prisms their name need **phase correction coatings** to keep light reflecting through those surfaces from interfering and getting darker and smudgy. The cheapest roof prism binoculars probably don't have this needed "Phase Correction" or "**P-coating**" on those surfaces. Their image will lack the detail and "definition" of better optics.

Another surface on the Schmidt prism, in the commonly used Schmidt-Pechan roof prism set, needs a reflective **mirror coating**, similar to the reflective coating on the mirrors in your house, to keep the light going along the path. While the mirrors in your house probably use aluminum, which reflects about 82% of the light, a more expensive silver coating can reflect 87% - 92% of the light. Stepping up in price, one can get a more expensive oxygen-free "HR" coating of either aluminum or silver – the extra steps to keep oxygen away make the metal surface brighter, reflecting about 88 – 90% for the HR process aluminum coating, or 97 – 98% with the HR process silver. A still more expensive di-electric chemical multi-coating, with alternating layers of material of high and low refractive index, up to 64 or 70 carefully placed layers, can reflect over 99% of light across the visible spectrum. For a price. Note that all these mirror coatings are for Schmidt-Pechan roof prism binoculars only; porro prisms and Abbe-Koenig roof prisms already reflect 100% of the light at all reflecting surfaces and don't need a mirror coating, and the porro prisms don't need a phase correction coating. They all can still use the anti-reflective multi-coatings where the light goes in and comes out.

All of these various coatings are used to increase the light transmission efficiency of the binoculars, to yield a brighter, clearer image with less light getting lost along the way. More money will usually get better coatings and more light getting through the binoculars to your eyes with a brighter image with higher contrast.

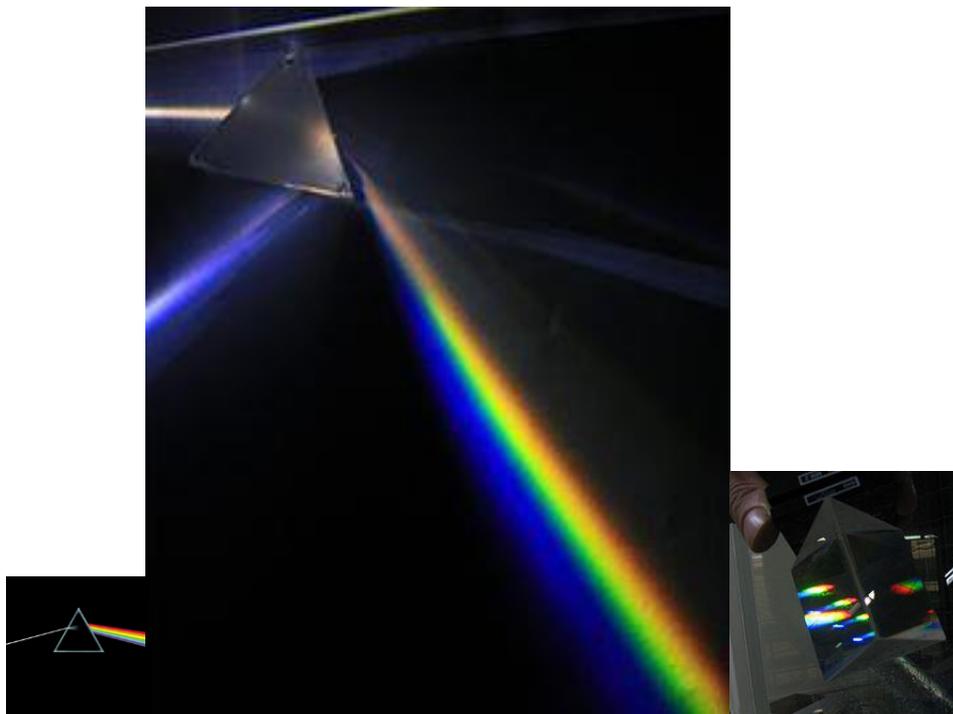
Prism glass - BK7 glass versus BaK-4 formula glass, and clear optical plastic

Another factor that affects how much light comes through the binoculars is the formula of glass used in the prisms. BaK-4 glass (Barium Crown formula no. 4) is more transparent (99+% in the prisms), but more expensive, than is BK-7 (Boron Crown formula no. 7) glass in the prisms (85 -

90%). So the more expensive BaK-4 glass in the prisms will yield a visibly brighter image, while the cheaper BK-7 glass will absorb about 15% of the light passing through. This is true for both porro prism and roof prism binoculars. Due to the shorter light path in the lenses, BaK-4 glass generally won't be used there, just in the prisms, which have a longer distance of travel for the light going through them. Except for special low-dispersion formulas, most high grade lenses used in quality optical equipment are made with BK-7 glass. Eye glasses, due to the very short distance going through the single lens to the eye, can even use clear plastic, which absorbs more light than glass does, but weighs less. For the longer light path through binocular prisms, the amount of light absorbed by clear plastic would be much more significant, making it impractical for plastic to be used in prisms or multiple sets of lenses in quality telescopes or binoculars.

Chromatic Dispersion

Most of you have, in school or elsewhere, seen the example of the visible light spectrum of colors as produced by rainbows and also with glass prisms which break up white light into the colors that it contains, spread out (“dispersed”) by the prism or rain droplets to show the colors therein. This is fine for prisms used for that purpose, but all transparent surfaces where light comes in at an angle do the same thing, to variable amounts, with their incoming light. This includes the glass lenses in the binoculars and telescopes. It causes light of different colors to fail to come to a focus at the same place, a problem when you want a full color, clear, sharp image.

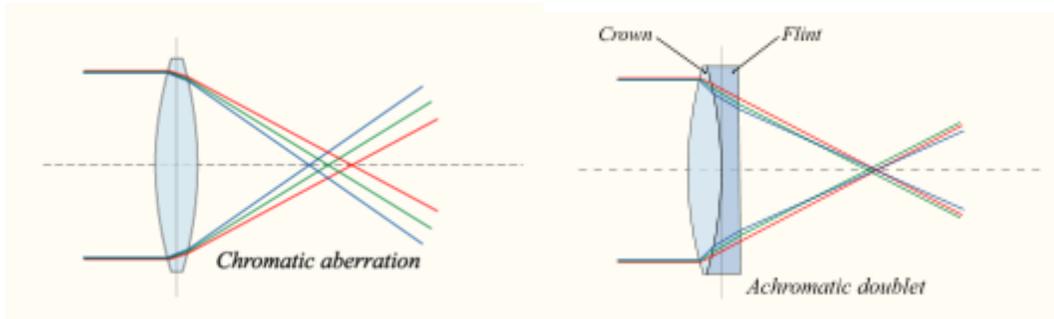


Images of prism and “rainbow” of colors – and on right, white lights seen through a prism with colors smeared by the dispersion.

MULTIPLE-ELEMENT LENSES

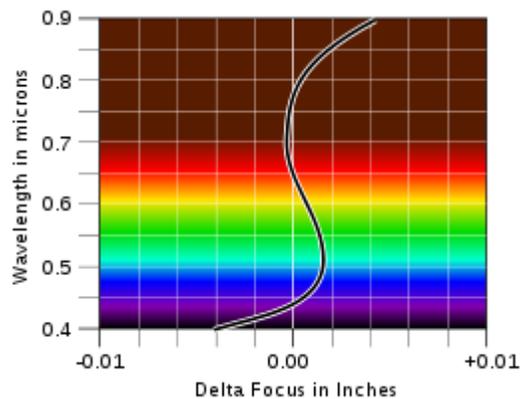
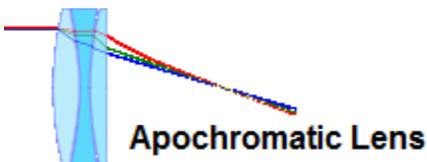
A partial fix for chromatic dispersion is the use of two-element "Achromatic" lenses, which have glass of two different formulas in them, compensating for this color "dispersion" and bringing two colors into the same focus. I believe all binoculars and telescopes offered for sale at all prices use achromatic (or better) objective lenses, and mid-priced and high-priced 'scopes and binoculars have achromatic or better (see below) lenses throughout. Sometimes this 2-element lens is called the Kellner lens, named for its inventor.

With a simple single-element lens, colors don't focus at the same point. Rainbow effect. A two-element "Achromatic" lens partially fixes the problem.



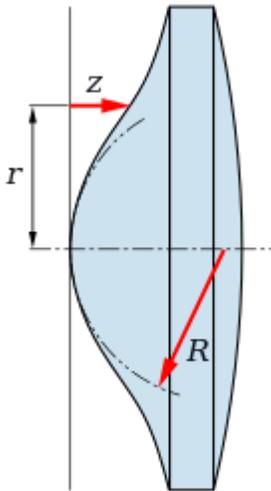
The two-element "Achromatic" lens can focus two colors at the same point, typically red and blue, leaving the other colors like yellow, green and purple a bit off.

Yet another step in cost and refinement is the "Apochromatic" lens, with three elements, each with differing dispersion properties, used to focus three colors of light onto the same focal point. Premium-class telescopes and binoculars (over \$1,000) generally have apochromatic objective lenses.



"Aspheric" lens elements

Another problem with refractive lenses is a geometric aberration in the way the light is bent, due to the varying thickness of the lens at different parts, thicker in the center and thinner out towards the edges. Some optical manufacturers make special "**aspheric**" lenses, also called "**Field Flatteners**" lenses, of complicated shapes to try to compensate for these effects and bring the outer part of the field of view into clearer, sharper focus, for a more uniform clarity across the field of view. They try to make the image "flatter", more precisely focused across the full width of the image, not just in the center. This does introduce a "coke bottle" effect which bends the sides of the image a bit, more noticeable at lower magnifications than at higher magnifications. I've seen this with the premium Zeiss binoculars I used to have, and in a pair of Swarovski premium-class binoculars I tried out. I consider it a fully acceptable trade-off for the clarity of the image presented.



Premium-class binoculars and telescopes ("premium" and "elite" groups in this article) use a three-element "Achromatic" objective lens to reduce color dispersion, and 2-element eyepiece lenses with the "field flattener" / "Aspheric" shapes, for focus uniformity across the field of view. This produces a noticeably better image with more clarity, edge-to-edge sharp detail, and less eye strain for the observer when using the optics for extended periods of time.

Special extra-low dispersion glass formulas

Another, additional partial solution is to use a more expensive formula of glass called "low dispersion" glass, or XP, HD, ED, or FL or HT glass. The various low-dispersion formulas differ in cost and effectiveness in reducing chromatic dispersion. These lenses use the low-dispersion formula glass in the main part of the lens. They still are multiple-element lenses (see above), to focus more than one color at a time. Note that the "HD" label in some sales literature is actually quite vague, since it can refer to ED glass with top-grade anti-reflective coatings, or to a fluoride glass formula. Fluoride (FL) glass, the highest-performing formula, has been with us in apochromatic lenses since 1963, and is still very expensive. The newer HT formula, a special variety

of fluoride glass, appeared in 2013, and is even more expensive. Lenses with fluoride ion formula glass steps premium class binoculars up to the top elite class, and doubles their price. The new 'HT' Schott formula is a type of fluoride glass with a higher transparency than most other glass formulas, letting about 2% more light through. This is featured in the new Zeiss "HT" and "SF" lines. Leica, another elite optical binoculars maker, is licensing the use of this Schott glass in their most expensive model, "Ultravid Plus", to keep up with the Zeiss models.

Most of these aberration problems, and some of their partial solutions, have been with us for centuries, addressed by astronomers wanting to get wide-field photos of the night sky without distortion or loss of focus across their photographic films. Some of the low-dispersion glass formulas have been around at least since the 1930's, while others, especially the new top-of-the-line FL formulas with fluorine ions in the glass, are newer. The introduction of ED and FL glass into binoculars and spotting telescopes for bird watching is relatively new and still very expensive.

SPOTTING TELESCOPES

With their higher magnification, spotting 'scopes will need the better lenses to reveal small details on distant birds, which is what the 'scopes are for.

A recent innovation in **spotting telescopes** has been the introduction of the **angled eyepiece**. This is mostly useful for having a 'scope set up on a tripod when observers of varying heights want to look through the 'scope. Taller observers can simply bend a little lower to view through the angled eyepiece, while shorter observers stand up straight and look through. With a straight-through 'scope, taller observers have to hunch down to look through a 'scope if it's low enough for the shorter observers to see through.



Straight-through and angled spotting telescopes

'Scopes also offer zoom eyepieces, very useful for scanning through a group of birds at a lower magnification, then zooming in on one particular bird for a closer look.

My Alpen 788, \$415 (Amazon, Mar. 2015), and the Nikon Prostaff, \$600, are good for viewing birds out to about 50 - 75 yards distance. At that range, they get an image which usually seems as good as the top-grade 'scopes. But for greater distances or for the tiniest details on distant, small birds a more expensive 'scope is needed. For steps up, a Bird Watchers Digest article in 2009 recommends the Vortex Viper, about \$900, and Vortex Razor, about \$1,600 at Eagle Optics, and then for still more distant or smaller details, step up to the top-of-the-line models by Swarovski,

Leica, Nikon (Fieldscope), Zeiss and Kowa, costing about \$2,600 to \$4,000 (Eagle Optics, Adorama, sportoptics.com). These top five are roughly tied in optical quality. Both 65mm and 80mm lens models are popular, but the 80mm models usually come with higher magnification available. Scores suggest there *might* be a tiny optical advantage with the Swarovski and Kowa models, but that's a matter of opinion among the reviewers. And the Zeiss Diascope can zoom up to 75x, while the other 80mm scopes stop at 60x. (60x and 75x - same ratio as 8x and 10x binoculars). The higher-priced scopes can make out smaller details at greater distances, which is what a 'scope is for.

So what's out there now? - the more complete listing, with spec's

There are plenty more models than I show in my listings; those I do show have been chosen because I've seen reviews indicating that they probably are of good quality for the price; those brands and models not shown either got poor reviews for the price, or simply did not appear in any of the comparison review articles I've read, and therefore are of unknown quality. The majority of the mid-grade roof prism models with all 2-element lenses, having basically the same design, are probably very similar in quality, varying mostly by mirror coatings or lens glass formula, or possibly by the anti-reflective coatings on air-to-glass surfaces or other factors.

ECONOMY ROOF PRISM BINOCULARS

These are economy-class, with single-element eyepiece lenses and no phase coatings. I list two ultra cheap roof prism mini's which are NOT waterproof and one that is. (The funny-looking font appearing below is used to keep columns straight; the Garamond font used through most of this article won't line up columns properly.) Prices as of March, 2015.

“FoV” = Field of View; “relief” = eye relief, “focus” = close focus distance

***Tasco Essentials 165RB**

| size | price | FoV | relief | focus | weight | |
|--|-------|------|--------|-------|--------|-----------------|
| 8x21 | \$11 | 383' | | | 6.6 oz | \$10.50 Adorama |
| 4 stars 121(!) reviews, a best seller at Adorama | | | | | | |

***Bushnell Powerview**

| size | price | FoV | relief | focus | weight | |
|--|-------|------|--------|-------|--------|--------------|
| 8x21 | \$12 | 378' | 10mm | 21 ft | 6.9 oz | \$12 Adorama |
| 4 stars 291(!) reviews, best seller at Adorama | | | | | | |

The following two are waterproof models available for a bit more, and being roof prism models they will tolerate more abuse than the more fragile porro prism models in the economy class.

Tasco Sierra TS825D

| size | price | FoV | relief | focus | weight | |
|------|-------|------|--------|--------|---------|--------------|
| 8x25 | \$17 | 350' | 15mm | 6.5 ft | 11.7 oz | \$32 Adorama |

Tasco Sierra TS 1042D

| | | | | | | |
|-------|------|------|------|---------|---------|--------------|
| 10x42 | \$44 | 293' | 15mm | 6.05 ft | 25.0 oz | \$44 Adorama |
|-------|------|------|------|---------|---------|--------------|

I don't recommend 10x miniature models, which are available for sale, because the image will jump around too much to make out much detail in the image. If you want a miniature, I'd limit the magnification to 8x or less. A miniature with 5x, 6x or 7x magnification would be much better.

One club member reports that his best-selling Bushnell Powerview 8x21 (not waterproof), listed above, did not deliver the "definition", i.e. fine focused details, of his newer \$250 Nikon Monarch full-size binoculars (a recommended mid-grade model).

Waterproof roof prism binoculars are more durable than porro prism models and will tolerate more abuse in the field. None of these economy roof models can match the image quality of the recommended economy 7x35 porro prism models listed in the next group below.

These cheap mini's might, however, be somewhat useful as pocket-size spares, and as starters for kids who can play with them and possibly learn to be more responsible, and "graduate", as they get older, to better binoculars, like the \$25 porro prisms models listed below.

Sort of example: as a kid, I owned a very poor quality "Space Telescope" gotten through a cereal box offer - a Galilean type telescope, 12x19mm, no sharp focus, couldn't resolve moon craters, but I thought it was the most wonderful possession I ever had as a kid; the color fringes (chromatic aberration) around the edges were a big bonus. For me, it was the most "Wonderful Toy" above all others, ever. I actually still have it as a sentimental relic from my childhood. It's useless for serious viewing of much of anything, but it was such a wonder for me when I was a kid.

ECONOMY PORRO PRISM BINOCULARS

The two following are ****porro prism, not waterproof**** but probably the best choice of the bunch, especially for beginners and casual users – note that cheap roof prism binoculars will not match these in optical quality, unless they cost \$80 or more, which is entry price into the next Mid-Priced group which does have significantly better optics and image. Still economy class, with 2-element objective lens and single-element eyepiece lenses.

“FoV” = Field of View; “relief” = eye relief, “focus” = close focus distance

****Bushnell Falcon**

| size | price | FoV | relief | focus | weight | |
|--|-------|------|--------|-------|--------|-------------|
| 7x35 | \$23 | 420' | 12mm | 20 ft | 21 oz | \$23 Amazon |
| 4.5 out of 5 stars, 82 Amazon customer reviews | | | | | | |

****Tasco Essentials Zip**

| size | price | FoV | relief | focus | weight | |
|--|-------|------|--------|-------|---------|-------------|
| 7x35 | \$30 | 500' | | | 22.4 oz | \$24 Amazon |
| 4.5 out of 5 stars, 21 Amazon customer reviews | | | | | | |
| - widest field of view of any binoculars in this listing | | | | | | |

It may be possible to upgrade from these economy porro prism binoculars and go to waterproof models with BaK-4 glass in the prisms, producing a brighter image. There are some more expensive porro binoculars which are advertised as shock resistant and waterproof. I couldn't find any information on the glass formula used in the Leupold BX-1's prisms, and must assume it's still the cheaper BK7, not the clearer BaK-4. (BK7 is Boron Crown formula #7, BaK-4 is Barium Crown formula #4). I would otherwise expect binoculars costing \$90 or more to have the clearer BaK-4 glass in the prisms; all of the "Mid-Grade" Group (\$90-\$500) binoculars in my listings do have BaK-4 glass prisms and achromatic lenses throughout; these porro's probably don't.

At their price range, some of the following, especially the Nikon action models, **should**, but apparently **don't**, have 2-element achromatic lenses throughout, as revealed by optics scores. The mid-grade group which follows does. Without achromatic eye lenses, these models will belong in the "economy" class despite the price, and they just won't be able to compete with the mid-grade group in image quality.

Nikon Aculon porro

rubber armored, BaK-4 glass, NOT WATERPROOF, but claims to have “aspheric field flattener lens elements”.

The Cornell review clearly shows the optics of these to be typical for the economy class, not up to mid-grade class optical level, despite the aspheric lenses, which evidently are single-element lenses.

“FoV” = Field of View; “relief” = eye relief, “focus” = close focus distance

| size | FoV | relief | focus | weight | price | |
|-------|-----|---------|---------|---------|---------|--------|
| 7x35 | 488 | 11.8 mm | 16.4 ft | 24.2 oz | \$74.95 | Amazon |
| 8x42 | 420 | 12 mm | 16.4 ft | 26.6 oz | \$75.80 | Amazon |
| 10x42 | 315 | 11.6 mm | 16.4 ft | 26.8 oz | \$83.69 | Amazon |

Leupold BX-1 Yosemite waterproof Porro

| size | FoV | relief | focus | weight | price | supplier | best price |
|-------|------|---------|---------|---------|----------|----------|------------|
| 6x30 | 420' | 18.5 mm | 15.7 ft | 17.0 oz | \$83.00 | Adorama | |
| 8x30 | 389' | 15.5 mm | 10.0 ft | 17.0 oz | \$94.95 | Adorama | |
| 10x30 | | | 11.0 ft | 17.0 oz | \$110.00 | Amazon | |

Leupold BX-1 Rogue waterproof porro

| size | FoV | relief | focus | weight | price | supplier | best price |
|-------|------|---------|---------|---------|----------|----------|------------|
| 8x42 | 341' | 16.5 mm | 24.0 ft | 18.5 oz | \$139.95 | Adorama | |
| 10x42 | 304' | | 21.0 ft | 24.2 oz | \$134.95 | Adorama | |

Vortex Fury 6.5 x 32 - apparently discontinued; not on Eagle site.

Closest equivalent is:

Vortex Raptor - 0-ring sealed, nitrogen filled, fog proof, waterproof, BaK-4 glass porro prisms, rubber armored.

| size | FoV | relief | focus | weight | price | supplier | best price |
|--------|------|--------|-------|---------|----------|--------------|------------|
| 6.5x32 | 410' | 20 mm | 15 ft | 17.3 oz | \$95.00 | Eagle Optics | |
| 8.5x32 | | | | | \$100.00 | Eagle Optics | |

These models carry a price which would better fit for models in the Mid-grade group with all 2-element lenses (including eyepiece lenses), but these have only single-element eyepiece lenses, as revealed in optical scores in the comparison studies. The sales literature of most binoculars does not specify lens types, which make such an impact on optic performance.

The older Vortex Fury model was recommended by Wayne Mones on the Audubon website, from personal use.

Pentax Papilio and Papilio II ultra close focus for butterfly watchers

6.5 x 21 or 8.5 x 21 porro prism binoculars with unique mechanism to compensate for parallax at the 1.6 ft ultra-close focus and aspheric eyepiece lens elements. Pentax says the aspherics are critical for compact binoculars. These ARE mini's, and the 8.5x models will suffer from the jumpy image problem. They are very light weight, and easily fit into a pocket. The eyepieces move for focus; these are NOT waterproof. The Papilio models were designed, and named, for butterfly watching.

These do have BAK-4 glass in the prisms, for an even brighter image in full daylight conditions than most of the economy and mid-grade binoculars do. Most butterfly watching is done in full daylight in open areas with flowers attracting the butterflies, so dim light viewing conditions aren't very important in this use. For bird watchers, birds in the deep woods near dawn or twilight would be harder to see, due to the small exit pupil. Being mini's, the 6.5x models have an exit pupil of 3.23, and the 8.5x model exit pupil is 2.47, both of which require full daylight for the image to be fully as bright as what you can see with larger binoculars. But larger binocular models don't offer the ultra-close focus of the Papilio. The Papilio II models aren't shipping yet as of 2/11/15. No info on what makes the -II models different; they seem to have the same spec's and price on the Pentax website.

Note that these models are mini's, and the 8.5x model may have the jumpy image problem.

bright = relative brightness ; might reflect transmission performance

“FoV” = Field of View; “relief” = eye relief, “focus” = close focus distance

| | | FoV | eye | close | bright | weight | price | | |
|------------|----------|-----|-----|-------|--------|--------|-------|---------|---------|
| Papilio | 6.5 x 21 | 393 | 15 | 1.6' | 10.2 | 10.2 | \$100 | Amazon | 3/9/15 |
| Papilio | 8.5 x 21 | 315 | 15 | 1.65' | | 10.2 | \$120 | Amazon | 3/9/15 |
| Papilio II | 6.5x21 | 393 | 15 | 1.6' | | 10.2 | \$126 | Adorama | 2/17/15 |
| Papilio II | 8.5x21 | 315 | 15 | 1.65' | 6.3 | 10.2 | \$146 | Adorama | 2/17/15 |

** The following Nikon Action Extreme EX porro prism series is nitrogen-purged & sealed waterproof, and claims to be shock resistant.

These Nikon's do have BaK-4 glass in the porro prisms. Optic scores from the comparison study in 2005 are well below those of the mid-grade group (with 2-element eyepiece lenses) below. And as Porro's, they are bulkier and heavier than roof prism binoculars of the same objective lens size. The prices should place them with the mid-grade group, but optics scores aren't up to the mid-grade group and reveal that they still have only single-element eyepiece lenses.

| Nikon Action EX | | | | | | price | | |
|-----------------|------|---------|---------|---------|-------|----------|------------|--|
| size | FoV | relief | focus | weight | price | supplier | best price | |
| 7x35 | 489' | 17.3 mm | 16.4 ft | 28.2 oz | \$122 | Adorama | | |
| 8x40 | 429' | 17.2 mm | 16.4 ft | 30.2 oz | \$129 | Adorama | | |
| 10x50 | 341' | 17.2 mm | 23 ft | 35.8 oz | \$166 | Adorama | - | |

One of our bird club members uses the Action 10x50's. I haven't tried them myself. The 2005 study rated these well below any of the mid-grade group in optical image quality.

At these prices, one can do much better by buying a model from the next group, Mid-grade, with BAK-4 glass in the prisms and two-element “Achromatic” lenses throughout, not just in the objective lenses.

GROUP THREE, MID-GRADE BINOCULARS, \$90 - \$500 (and up)

mostly sealed roof prism binoculars, a couple of porro prism models also here

This class of binoculars features 2-element achromatic lenses throughout, BaK-4 glass in the prisms, and in roof prism models, phase corrective coating on the "roof" surface of the Pechan prism and a mirror coating on one of the Schmidt prism surfaces.

I personally recommend that anyone contemplating spending \$90 or more should consider purchasing a model from this group (or higher), due to the higher optical performance and the more durable construction, protecting your investment in the optics.

Most roof prism models in this group use an aluminum mirror on the surface of the Schmidt prism, same as in the mirrors in your home. The Swift Ultras, Alpen, and some others enhance the aluminum coating with an "HR process" keeping oxygen out, for a brighter surface. Older Eagle Optics Rangers and the Atlas Intrepid ED models used a more expensive silver coating for a still brighter surface. The newest Eagle Optics Rangers and Monarch models step up to a di-electric mirror coating for 99% plus reflectivity, brightest available, previously only found in premium-grade or elite-grade binoculars. They previously used silver coatings; probably the increasing market price of the precious metal made the upgrade to the di-electric coating feasible.

In the Baltimore Bird Club demo and talk at Cyburn, September 2013, the mid-grade roof prism binoculars on the table clearly did out-perform economy porro prism binoculars in image quality, according to the people who tried them out and compared them.

In that tryout, I also noticed a similar step up in image quality and clarity from the mid-grade to the premium-class Zeiss binoculars on the table, despite the fact that they were older than most of the other binoculars on the table, and didn't have any of the fancy ultra-low dispersion glass formula in the lenses as used in today's premium and elite class binoculars.

Considering what I've seen in several models, I suspect that most of the mid-grade binoculars actually are very similar in optical quality, probably because they are all of the same basic design, with Schmidt-Pechan roof prisms, phase correction coatings, and 2-element achromatic lenses throughout, differing slightly in brightness of the image, due to the type of mirror coating or in some cases an improved glass formula with lower color dispersion in the lenses. According to actual comparison reviews, the lens glass formula doesn't guarantee better optical performance.

There are also some sealed, waterproof porro prism binoculars with BaK-4 glass in the prisms, including the Swift Audubon series (with one roof prism model added among them). Swift Ultra previously included some porro models. (I bought one and subsequently broke it.)

The waterproof porro's are bulkier and heavier than roof prism models of the same objective lens size, and are more fragile. None of the porro models need or use a mirror coating or a phase correction coating on their prisms.

The three following series are about the cheapest in mid-grade roof prism models, but have major endorsing recommendations and are known as true quality waterproof binoculars.

The Shrike (\$100-\$110) was rated least expensive waterproof, quality binoculars by a couple who write for Bird Watchers Digest, who also conducted one of the major comparison studies and

ratings of binoculars in medium and high-price categories - but this model does have below average field of view. They did also score below average for the mid-grade group in optical quality (at a lower-than-average price) in the Cornell study (fall 2013).

“FoV” = Field of View; “relief” = eye relief, “focus” = close focus distance

Eagle Optics Shrike

| size | price | FoV | relief | focus | weight | |
|-------|-----------|------------|-----------------|---------|---------|--------------------|
| 8x42 | \$100 | 341' | 17.6mm | 13.1 ft | 23.2 oz | \$100 Eagle Optics |
| | - 5 stars | 18 reviews | Eagle customers | | | |
| 10x42 | \$110 | 304' | 13.6mm | 13.1 ft | 22.4 oz | \$110 Eagle Optics |
| | - 5 stars | 5 reviews | Eagle customers | | | |

The Atlas Optics Radian (\$130-\$140) was rated least expensive binoculars recommended for bird watching by the staff at Eagle Optics internet store, overlooking their own store-brand Shrike recommended above by Bird Watchers Digest, and the Radian does have closer focus and a slightly wider field of view than the Shrike has, for an extra \$30. Rated average for the mid-price group in optical quality in the newest Cornell review. And a bargain at the price.

Atlas Optics Radian

| size | price | FoV | relief | focus | weight | |
|-------|-----------|------------|-----------------|--------|---------|--------------------|
| 8x42 | \$130 | 375' | 17.5mm | 6.5 ft | 23.0 oz | \$130 Eagle Optics |
| | - 5 stars | 36 reviews | Eagle customers | | | |
| 10x42 | \$140 | 305' | 15.5 mm | 6.5 ft | 23.0 oz | \$140 Eagle Optics |
| | - 5 stars | 23 reviews | Eagle customers | | | |

Bushnell Nature View - most Nature View models are unsealed porro prism models, but the three below are sealed roof prism models with rubber armor.

These should be competitive with the Shrike and Radian models above, both in price and quality. Note the much better close focus with the 8x models and field of view better than either the Shrike or the Radian for all three models. The Radian, not the Nature View, has the closest focus among these three lines for the 10x binoculars.

Bushnell Nature View

| size | price | FoV | relief | focus | weight | |
|-------|---------------|-------------------|---------|-------|---------|---------------|
| 8x32 | \$ 91 | 393' | 16.6 mm | 5 ft | 16 oz | \$ 78 Adorama |
| | - bargain for | mid-grade binoc's | | | | |
| 8x42 | \$102 | 393' | 17.5 mm | 5 ft | 23.1 oz | \$ 94 Adorama |
| 10x42 | \$118 | 325' | 15.2 mm | 13 ft | 22.4 oz | \$120 Adorama |

Here are some more models of mid-grade roof prism binoculars, gradually working up in price:

Leupold BX-2 Acadia

| size | FoV | relief | focus | weight | best price and where |
|-------|------|--------|--------|---------|----------------------|
| 8x32 | 394' | | 5.0 ft | 18 oz | \$145 Amazon |
| 10x32 | 288' | | 5.0 ft | | \$156 Amazon |
| 8x42 | 394' | 15.5mm | 7.5 ft | 23.1 oz | \$184 Amazon |
| 10x42 | 368' | 15.5mm | 9.0 ft | 23.5 oz | \$215 Amazon |

Leupold - I have some confusion with their "Cascades" and "Acadia" model lines. The website implies that the more expensive "Cascades" have rubber armor and the "Acadia" does not, but sites

like Amazon and Adorama put some question to that. The website does not otherwise specify any obvious difference between "Acadia" and "Cascades" models, but the spec's and prices differ, and the Acadia models have closer focus than the more expensive Cascades.

My sister-in-law has the Leupold BX-2 Acadia 10x42's (\$184) and they seemed OK to me when I looked through them. My Swift Ultra's were slightly brighter; I believe the Ultras have HR process aluminum mirror coating; the Leupold probably has the standard aluminum mirror without the extra HR process brightening. I did notice one awkward feature in the Leupold Acadia model - instead of a stiff rotating eyepiece for bringing both eyes to focus together, this model uses a lever next to the regular focus knob for bringing both eyes to focus, and it's easily dislodged, requiring more frequent adjustment to get proper focus alignment. Both models have BaK-4 glass roof prisms. Either one would do fine for birding, no complaint. This is very probably true for almost any of the mid-grade roof prism models offered for sale by all makers; the basic design is the same, even though slight differences show up in the field of view, eye relief, close focus and weight. Optics score differences in the studies may have been due to the brighter image with models with better mirrors, or perhaps the formula of glass in the lenses. Four models at the end of this list of mid-grade models feature ED glass lenses.

continuing with more -

Bushnell Legend Ultra HD series - rubber armored, "extra-low dispersion", "ED Prime Glass" objective lenses (similar to Alpen Apex XP?). Year 2009 upgrades to objective lens glass formula, more Field of View at cost of less eye relief. Magnesium body, and improved antireflective lens multi-coatings.

These were rated bottom of the group optically in the 2011 comparison review by Bird Watchers Digest, despite the improved glass formula and improved antireflective coatings. But they're still recommended by Wayne Mones on the Audubon website; this reinforces my impression that virtually all mid-grade roof prism binoculars should be good for bird watching and meet with his (and my) approval.

"FoV" = Field of View; "relief" = eye relief, "focus" = close focus distance

Bushnell Legend Ultra HD series

| size | FoV | relief | focus | weight | price & where | |
|-------|------|---------|--------|---------|---------------|---------|
| 8x36 | 426' | 15.4 mm | 6.2 ft | 20.7 oz | \$192 | Amazon |
| 10x36 | 341' | 15.4 mm | 6.2 ft | 20.7 oz | \$289 | Adorama |
| 8x42 | 420' | 17 mm | 6.5 ft | 22.4 oz | \$200 | Amazon |
| 10x42 | 340' | 15.2 mm | 6.5 ft | 24.7 oz | \$204 | Amazon |

Vortex Diamondback

| size | FoV | relief | focus | weight | price & where | |
|-------|------|---------|--------|---------|---------------|--------------|
| 8x32 | 420' | 10 mm | 5.3 ft | 18.4 oz | \$190 | Eagle Optics |
| 10x32 | 420' | 10 mm | 5.3 ft | 18.4 oz | \$200 | Eagle Optics |
| 8x42 | 420' | 18.0 mm | 4.5 ft | 25.2 oz | \$220 | Eagle Optics |
| 10x42 | 345' | 16 mm | 5 ft | 24.4 oz | \$230 | Eagle Optics |

"Wild Bird Centers" (store brand, manufacturer unknown)

| size | price | FoV | relief | focus | weight | best price and where | |
|------|-------|----------|--------|--------------|--------|-------------------------------|--|
| 8x42 | | no specs | | \$240 (2013) | | at the Wild Bird Center store | |

10x42 no specs \$250 (2013) Kevin Graff loves his 10x WBC's.

- - - NIKON MONARCHS - - -
these are the standard to compare with other mid-grade binoculars.

Nikon Monarch 3

| size | FoV | relief | focus | weight | best price 11/27/13 |
|------|------|--------|--------|---------|---------------------|
| 8x42 | 330' | 24.1 | 9.8 ft | 24.7 oz | \$227 |

Nikon Monarch 5 - see the ED group, below

Nikon Monarch ATB

| size | FoV | relief | focus | weight | best price 11/27/13 |
|-------|------|--------|--------|---------|---------------------|
| 8x42 | 330' | 19.6 | 8.2 ft | 21.5 oz | \$297 |
| 10x42 | 299' | 17.4 | 9.8 ft | 24.7 oz | \$247 |

Nikon Monarch ATB (WA)

| size | FoV | relief | focus | weight | best price 11/27/13 |
|-------|------|--------|--------|---------|---------------------|
| 10x42 | 314' | 15.5 | 8.2 ft | 21.1 oz | \$327 |

Nikon Monarchs come in a confusing collection of models of various vintages and prices. Models include

Monarch 3, -DCF, (silver mirror), (discontinued models still in stock)

Monarch 5, -ATB, and -7 models (dielectric mirror)

Monarch ATB has wide angle and extra light weight, no ED glass mentioned in the advertising literature.

Monarch 7 has ED glass, rubber-armored, "super" lens and prism antireflective coatings.

\$477 at Adorama. No mention in the 7's advertising blurb about "apochromat" or "field flattener" lenses. I believe those features are reserved for the premier class (and premier priced) Nikon EDG models.

One club member tried several models including the \$300 Eagle Optics Ranger SRT (see below) and decided his favorite was the Monarch. But now he currently uses the slightly more expensive Alpen Apex (next). I need to check which Monarch model line he has; I suspect it's the Monarch 5 with ED glass and the dielectric mirror, \$297 at Adorama, see the ED grouping coming later in this list.

Alpen Apex XP (model numbers in the 600's series)

| size | FoV | relief | focus | weight | best price 11/27/13 |
|-------|------|--------|--------|--------|---------------------------------|
| 8x32 | 340' | 16mm | 4 ft | 19 oz | \$269.10 Amazon |
| 10x32 | 314' | 16mm | 4 ft | 19 oz | \$279 Amazon , \$310 Adorama |
| 8x42 | 341' | 20mm | 5.0 ft | 22 oz | \$287.10 Amazon , \$319 Adorama |
| 10x42 | 315' | 16mm | 5.0 ft | 22 oz | \$315 Amazon , \$350 Adorama |

The Alpen Apex earlier model 493 (8x42) was rated slightly below average optically in the Bird Watchers Digest comparison in 2007, but the newer XP model 693 (8x42) scored near the top, well above most others, including Monarch, in the 2011 reviews. The club member above also likes his new Alpen Apex 8x42 binoculars as much as his Monarch 5 ED's.

I suspect a higher-performing grade of low-dispersion glass may be in the lenses, or perhaps a better mirror coating made the difference. One source reports the upgrade was in diopter adjustment and in anti-reflective lens coatings. The published field of view, eye relief, and close focus spec's remain the same as for the older model 493 (8x42).

Eagle Optics Ranger - now uses di-electric coating (99% reflectivity), not aluminum or silver (92 - 98% reflectivity), for the mirror. The older Ranger SRT used a silver mirror. Ranger also comes with a model featuring ED glass, but costs more than the four ED model lines featured later in this listing.

Eagle Optics Ranger

| size | FoV | relief | focus | weight | best price |
|-------|---------|-------------|--------------------|---------|-----------------------|
| 8x42 | 341' | 19.5mm | 5.2 ft | 22 oz | \$300 at Eagle Optics |
| - | 5 stars | 202 reviews | by Eagle customers | | |
| 10x42 | 314' | 16 mm | 5.2 ft | 21.6 oz | \$309.99 Eagle Optics |
| - | 5 stars | 102 reviews | by Eagle customers | | |

- The older Ranger SRT (silver mirror) is the high quality 8x binocular that (barely) beat my Swift Ultra 10x in fine details seen reading fine print at 15 ft distance, mainly due to slightly brighter image with higher contrast. They now use an even brighter di-electric mirror coating, brighter than the aluminum mirror most models use.

| | | | | | | | |
|-------------------|-------|------|--------|------|-------|----------|---------|
| Swift Ultra 8x42 | \$301 | 341' | 19.5mm | 6 ft | 24 oz | \$301.30 | Adorama |
| Swift Ultra 10x42 | \$302 | 314' | 16 mm | 6 ft | 25 oz | \$302.34 | Adorama |

- These 10x are my old standard binoculars.

Note the smaller field of view with the higher magnification of 10x, compared to 8x binoculars. The Swift Ultra roof prism model has a slightly, but noticeably, brighter image than most roof prism models due to a low-oxygen “HR” process used in depositing the aluminum coating on the Schmidt prism. See mirror coatings earlier in this article.

Swift also has an Ultra in porro prism, weighing 28 oz, “Ultra Lite”, with waterproofing. I actually bought those first, but they broke at the eyepiece, so I went for the more durable roof prism binoculars which are now my standard. The roof prism binoculars proved themselves by surviving the "dog wars" - chewed up by the family dog but still working just fine. I believe the porro models might be slightly better optically than my roof prism standard, and better than the current Swift Audubon series binoculars offered for sale at a higher price. But they failed my durability test. Note their longer close-focus spec compared to my current standard roof prism binoculars. (Spec's for the Ultra roof prism models above, for the Ultra porro models below.) Note that the 10x42 model is now offered by Swift only without the rubber armor as a “Horizon” model, but with the same lens coatings used by the Ultra models. (The Horizon roof models have cheaper anti-reflective lens coatings, lack the rubber armoring of the Ultra models, and probably aren't up to the optical quality of the Ultra models.)

| | | | | | |
|---------------------------|----------------|------|-------|-------|-------|
| **Swift Ultra porro 8x42 | approx. \$300* | 341' | 18 mm | 13 ft | 28 oz |
| **Swift Ultra porro 10x42 | approx. \$300* | 288' | 18 mm | 13 ft | 28 oz |

The Swift Audubon binoculars (below) show what one can do with putting money into porro prism binoculars, making them more durable and waterproof and putting in the optical coatings. One roof prism “twin” is sibling to the “regular” porro model, and one ED porro model is offered. The ED model costs more and has better optical quality due to the glass formula. All three are 8.5 x 44.

Swift Audubon porro

| size | price | FoV | relief | focus | weight |
|------|-------|-----|--------|-------|--------|
|------|-------|-----|--------|-------|--------|

| | | | | | | | |
|--|-------|------|--------|-------|--------|---------|-----------|
| 8.5x44 | \$329 | 430' | 16 mm | 14 ft | 24 oz | 4 stars | 7 reviews |
| Swift Audubon roof | | | | | | | |
| size | price | FoV | relief | focus | weight | | |
| 8.5x44 | \$388 | 336' | 19 mm | 9 ft | 23 oz | 5 stars | 5 reviews |
| twin to the porro prism model, but with different spec's, lighter weight | | | | | | | |
| Swift Audubon porro ED | | | | | | | |
| size | price | FoV | relief | focus | weight | | |
| 8.5x44 | \$430 | 430' | 16 mm | 10 ft | 29 oz | 4 stars | 7 reviews |

I looked through the Audubon roof prism model, and found my Swift Ultra's were brighter. (Probably HR vs non-HR aluminum mirrors.) The Vanguards (in the ED group following) are brighter still, with brighter colors, especially in subdued lighting.

What about those Vortex models offered through Eagle Optics- ?

- Crossfire (about \$160), Diamondback (about \$220), Viper (about \$590), Razor (\$1,180)? What makes those models different? I think the Razor is a premium, but what about the differences among these other three models of roof prism binoculars, if all mid-grade roof prism models are about equal? Mirror coatings? More? Does the Viper have aspheric/field flattener eyepiece lenses? Does the Viper also have a di-electric mirror? Does the Crossfire have cheaper lens coatings?

Also note the significantly lower optic score for the Bushnell Legend Ultra HD with the special grade glass, contrasting with the significant upgrade in optic score for the Alpen Apex XP vs the older non XP Apex in the 2009 comparison tests. The two Apex models used the same configuration, lens focal lengths, etc for the same field of view, close focus, eye relief etc , yet differ significantly in their optic scores. One source indicates improved lens coatings may have made the difference; I suspect there also is an improvement in lens glass formula, for lower dispersion. But improved lens glass formula didn't lift the Bushnell Legends up to the top at all, according to the reviewers.

= = special sub-class: mid-grade binoculars with ED glass = =

Here are four new mid-grade ED binocular models, \$250 - \$400. With the ED glass, these should have images with brighter colors. I found that, as with the premium and elite classes, most of these appear at the same price at Amazon, Adorama, and Eagle Optics. In this case, I suspect 2 of the 4 are distributed THROUGH Eagle Optics. Like most of the other mid-grade binoculars, these will have BaK-4 glass in the Schmidt-Pechan roof prisms, with phase corrective coatings. All lenses (including objective) will be 2-element achromats. They are O-ring sealed, waterproof, nitrogen-purged roof prism binoculars. They differ in their mirror coatings and reviewer ratings.

The Vanguard entry is the only one appearing in the BWD article of 2012. In their mid-grade group it bested all of the other mid-grade models. But they scored slightly BELOW average for mid-grade binoculars in the newer 2013 Cornell review. Probably the truth is somewhere in the middle. (I did notice narrow depth of focus when using them.)

The Cornell review (newest available review) placed the Monarch 5 (an ED model) at the top of the group. ((But note that this model has lower Field of View than most models in this group.))

The cheapest of the four, Atlas Intrepid ED, not only has the ED glass but also a silver mirror coating, brighter than the standard aluminum. **It also offers a 7x36 model, an upgrade alternative to the \$30 7x35 porro prism binoculars** and the **best close-focus** in this group of four models.

FoV = Field of View, in feet wide at 1,000 yards distance

eye = eye relief, in millimeters (mm)

close = close focus, in feet from the objective lens

weight = in ounces

Atlas Intrepid ED - silver mirror coating (brighter than aluminum)

| size | FoV | relief | focus | weight | price |
|-------|------|--------|--------|---------|-------|
| 7x36 | 477' | 16.8mm | 5.1 ft | 22.8 oz | \$300 |
| 8x42 | 420' | 17 mm | 6.5 ft | 26.6 oz | \$290 |
| 10x42 | 342' | 15.0mm | 6.5 ft | 26.6 oz | \$300 |

Vanguard Endeavor ED

| size | FoV | relief | focus | weight | price |
|-------|------|--------|--------|--------|--|
| 8x42 | 400' | 19.0mm | 8.2 ft | 26 oz | \$350 before \$50 mail-in rebate, \$300 net. |
| 10x42 | 340' | 16.5mm | 8.2 ft | 26 oz | \$350 before \$50 mail-in rebate, \$300 net. |

I bought the 10x42 Endeavor on sale in Sep. '13. Note a very narrow depth of focus, making it a bit more demanding getting these in focus, with more eye strain when they're just a bit out of focus. I did also confirm brighter colors in subdued lighting, compared to non-ED binoculars.

Nikon Monarch 5 (ED, with dielectric mirrors, brightest in group)

| size | FoV | relief | focus | weight | price |
|-------|------|--------|--------|---------|------------------------|
| 8x42 | 300' | 19.6mm | 8.2 ft | 21.5 oz | \$297 Adorama 11/27/13 |
| 10x42 | 288' | 18.4mm | 7.8 ft | 21.6 oz | \$326 Adorama 11/27/13 |

Note one distinct disadvantage to these otherwise top-of-the-line Mid-grade models Monarch 5's here - lowest Field-of-View of all models listed in this group.

Zeiss Terra ED - mid-grade ED, not premiums,

best close focus for 8x or 10x in this group

| size | FoV | relief | focus | weight | price |
|-------|------|--------|---------|---------|-------|
| 8x42 | 375' | 18mm | 5.25 ft | 25.4 oz | \$350 |
| 10x42 | 330' | 14mm | 5.25 ft | 25.4 oz | \$400 |

GROUP FOUR - PREMIUM BINOCULARS, \$900 - \$2,000

Binoculars in this class gain most of their superiority from a three-element Apochromatic objective lens, which can focus three colors to the same exact point, and eye piece (ocular) lenses with "aspheric" geometric correction for varying thickness in parts of the lens (see "Aspheric" earlier in this article, also referred to as "field flattener lenses"). This combination of Apochromatic and "Aspheric" corrections yields a significantly clearer image with less eye strain. Most of these will also have the di-electric iridescent mirror coatings and first-rate anti-reflective lens coatings. Once you've used any one of these models for while, you won't want to settle for anything less, if you can afford it.

Prices are generally about the same for Amazon, Adorama and Eagle Optics with these premium products.

Leica Trinovid (not the super low dispersion Fluorite lenses, a more economical alternative, still premium class). These Trinovids also uniquely sport THREE ocular lenses, plus focus lens and objective lens. (All of the other mid-grade, premium and elite models have two ocular lenses, a focus lens and an objective lens.)

| size | FoV | relief | focus | weight | price |
|-------|------|--------|---------|---------|-------------------|
| 8x42 | 378' | 15.5mm | 11.5 ft | 28.6 oz | \$1,449.00 Amazon |
| 10x42 | 324' | 16 mm | 11.5 ft | 28.0 oz | \$1,499.00 Amazon |

Nikon Premier - high-reflection silver coating, **not** the superior di-electric iridescent mirror

| size | FoV | relief | focus | weight | price |
|-------|------|--------|--------|---------|-------------------|
| 8x32 | | | | | \$1,196.95 Amazon |
| 8x42 | 367' | 20mm | 9.8 ft | 28 oz | \$1,449.00 Amazon |
| 10x42 | 314' | 18.5mm | 9.8 ft | 27.9 oz | \$1,599.95 Amazon |

Nikon EDG

Nikon EDG - ED glass, not the elite FL formula; they do have the aspherics and presumably the apochromatic objective lens. And these DO have the di-electric mirror coating on the Schmidt prism.

These aren't rated as high in article ratings as the elite models with fluoride glass.

| size | FoV | relief | focus | weight | price |
|-------|-----|--------|--------|---------|-----------------------|
| 7x42 | 420 | 22.1 | 9.8 ft | 27.7 oz | \$2,296.95 |
| 8x42 | 405 | 19.3 | 9.8 ft | 27.7 oz | \$2,296.65 - 2,399.95 |
| 10x42 | 342 | 18.0 | 9.8 ft | 27.9 oz | \$2,496.95 - 2,499.95 |

Zeiss Conquest HD transmission 90% + , T* coatings , **best value in class**

| "mid-sized" , 32 mm (less glass, lower weight and prices) | | | | | |
|---|------|--------|--------|---------|-----------------------------|
| size | FoV | relief | focus | weight | price |
| 8x32 | 420' | 16 mm | 4.9 ft | 22.2 oz | \$900 Amazon |
| 10x32 | 354' | 16 mm | 4.9 ft | 22.2 oz | \$910 Amazon |
| "full sized", 42 mm | | | | | |
| 8x42 | 384' | 18 mm | 6.5 ft | 28 oz | \$950 new, Amazon |
| 10x42 | 345' | 17 mm | 6.5 ft | 28 oz | \$924 new, 849 used, Amazon |

Zeiss is one of only two manufacturers to publish transmission figures for their binoculars, the other being Swarovski. Zeiss does so for both their Conquest model above, and for their new Victory HT and SF series in the elite class which follows. The Zeiss Conquest rated best-in-class for the premium group in the Cornell study (which called them "Mid-Priced"). They were not only best in class in performance, but also more affordable than any of their competitors as well.

Swarovski Companion CL - mid-size 30 mm offerings in green, tan or black

| size | FoV | relief | focus | weight | price |
|-------|-----|--------|--------|---------|----------------------------|
| 8x30 | 372 | 15 mm | 9.8 ft | 17.6 oz | \$ 949.00 Adorama 11/27/13 |
| 10x30 | 300 | 14 mm | 9.8 ft | 18.2 oz | \$1019.00 Adorama 11/27/13 |

Swarovski SLC - their non-fluoride full-size 42mm offerings

| size | FoV | relief | focus | weight | price |
|-------|-----|---------|---------|---------|----------------------------|
| 8x42 | 408 | 18.5 mm | 10.5 ft | 28.5 oz | \$1729.00 Adorama 11/27/13 |
| 10x42 | 330 | 16 mm | 10.5 ft | 28 oz | \$1800.00 Adorama 11/27/13 |

GROUP FIVE, ELITE BINOCULARS, \$1,700 - \$2,700

The expensive FL (fluoride ion) glass pushes Premiums up to the Elite state-of-the-art class, best that money can buy.

Leica and Nikon offer [7x binoculars](#) which could serve as an ultra-premium alternative to the economy \$30 porro prism 7x35's in group 2, or the \$300 Atlas Intrepid 7x36 in the top of the mid-grade group 3. With the better grade glass and the apochromatic objective and aspherics in the eyepiece lenses, they would offer the world's best view in a 7x binocular. At a price.

Leica Ultravid HD

Mid-size 32mm

| size | FoV | relief | focus | weight | price |
|-------|-----|-------------|--------|---------|---------|
| 8x32 | 404 | 13.3 | 7.2 ft | 18.9 oz | \$1,950 |
| 10x32 | 352 | 13.2 | 6.9 ft | 19.9 oz | \$2,050 |

Full-size 42mm

| | | | | | |
|-------------|------------|--|----------------|----------------|----------------|
| 7x42 | 420 | | 10.8 ft | 27.2 oz | \$2,150 |
| 8x42 | 390 | | 9.8 ft | 27.8 oz | \$2,000 |
| 10x42 | 336 | | 9.5 ft | 26.4 oz | \$2,300 |

Leica Ultravid HD-plus with the Schott HT glass for +2% light

Full-size 42mm

| | | | | | |
|-------------|------------|--|----------------|----------------|----------------|
| 7x42 | 420 | | 10.8 ft | 27.2 oz | \$2,400 |
| 8x42 | 390 | | 9.8 ft | 27.8 oz | \$2,450 |
| 10x42 | 336 | | 9.5 ft | 26.4 oz | \$2,500 |

Note - the 7x42 HD-plus is the highest-grade 7x model on the market.

Zeiss Victory FL - Zeiss has moved the 42mm models from the Victory FL line to the HT line. With Victory FL, choose 32mm or 56 mm objective size. The Zeiss website says these have the normal Schmidt-Pechan roof prisms, not the Abbe-Koenig roof prisms used in the HT binoculars.

I list only the "mid-sized" 32mm binoculars below.

These 32mm binoculars will weigh less, for people who don't want the regular full weight binoculars. This 32mm size is currently considered "mid-sized" and is growing in popularity.

These smaller Zeiss FL 32mm models weigh less and cost less than 42mm "full size".

But the lower weight in the hands might cause more image jitter for some users. The 2013 Cornell study gave these the highest (by a tiny fraction) optic score of all.

Prices as of 3/16/15, Zeiss Victory FL with 32mm objective lens:

| size | FoV | relief | focus | weight | price |
|-------|------|--------|---------|----------|---------|
| 8x32 | 420' | 15.5 | 6.56 ft | 19.75 oz | \$1,750 |
| 10x32 | 360' | 15.2 | 6.56 ft | 19.75 oz | \$2,000 |

The HT and SF models by Zeiss feature a new, proprietary Schotz HT high-transparency FL glass formula, and produce the brightest image of any binoculars on the market, with a published transmittance performance of 95% HT, with Abbe-Koenig prisms, and 92% SF, with Schmidt-Pechan prisms. (Swarovski has 90% transmittance, the only other manufacturer to publish a figure.) Most of the comparison reviewers hadn't seen the HT's yet when they did their reviews. Comments on the internet suggest these may possibly be overtaking the Swarovski models as the most popular elite class binoculars. The Cornell reviewers, who DID see these, rated them about the same as all the others in this group, a virtual three-way tie among Zeiss (both flavors), Leica, and Swarovski.

Zeiss Victory HT with Abbe-Koenig prisms and HT glass for 95% transmittance

| Size | FoV | relief | focus | weight | Amazon, Adorama, Eagle Optics prices |
|-------|------|--------|--------|---------|--------------------------------------|
| 8x42 | 408' | 16mm | 6.2 ft | 27.7 oz | \$2,250 |
| 10x42 | 330' | 16mm | 6.2 ft | 28.4 oz | \$2,300 |

prices as of 3/16/15

Zeiss Victory SF (new for 2014) 92% transmittance, HT glass, Schmidt-Pechan prisms

Featuring wider FoV angle, more eye relief, closer focus, ergonomic upgrades with fast-focus, shift weight towards the eyepiece end, slightly lighter weight, et. al.

| Size | FoV | relief | focus | weight | Amazon, Adorama, Eagle Optics prices |
|-------|------|--------|--------|---------|--------------------------------------|
| 8x42 | 444' | 18mm | 5.0 ft | 27.5 oz | \$2,600 |
| 10x42 | 360' | 18mm | 5.0 ft | 27.5 oz | \$2,650 |

prices as of 3/16/15

Zeiss hadn't shipped any SF's yet as of 3/16/15.

Swarovski EL Swarovision - FL lenses, 90% transmittance (only other transmittance data I have is the Zeiss). These seemed to be the best-sellers and highest-priced among the elite binoculars as of spring 2013, and have very good field of view, close focus, eye relief, and weight specs. The Swarovision 10x, Zeiss SF 10x and the Atlas Intrepid 10x (mid-grade) are the only 10x models in these listings to exceed 350 ft field of view. get a look at that best-in-class close focus these Swarovision can bring in their 42mm models (tied with the Zeiss SF series, not yet shipping). Mid-size and full size available.

| Swarovski EL SwaroVision | - these have very good spec's | | | | | |
|--------------------------|-------------------------------|--------|--------|---------|-------------|---------|
| size | FoV | relief | focus | weight | price range | |
| 8x32 | 423' | 20mm | 6.2 ft | 20.5 oz | \$2,200 | 3/16/15 |
| 10x32 | 360' | 20mm | 6.2 ft | 20.5 oz | \$2,300 | 3/16/15 |
| 8.5x42 | 399' | 20mm | 4.9 ft | 29.4 oz | \$2,530 | 3/16/15 |
| 10x42 | 336' | 20mm | 4.9 ft | 29.6 oz | \$2,500 | 3/16/15 |

Reviews seemed to indicate the Leica, Zeiss and Swarovski were tied at the very top for optical quality. The Swarovski's seem to be the best sellers of the bunch, with the Zeiss HT's possibly catching up to take the lead in sales. I'm not sure which is currently best-selling. Reviews generally show a three-way tie among Leica, Zeiss and Swarovski for top performance honors.

The Cornell reviewers came to the opinion that the Premium (\$1,000 - \$2,000) class group, costing a thousand dollars less, are close enough in quality that the extra money might not be justified for the small improvement going up to the FL glass Elite group.

internet binocular best price sellers:

Adorama <http://www.adorama.com/>

- often has the best price, but always compare price with Amazon

Amazon <http://www.amazon.com/>

- often has the best price, but always compare price with Adorama

B&H Photo <http://www.bhphotovideo.com/> has the Zeiss Victory SF series which is not found at either Amazon or Adorama 3/16/15

Eagle Optics <http://www.eagleoptics.com/> - generally not as deeply discounted, but several models come at Eagle prices exclusively, and exclusively through Eagle.

Best-Price (a price comparison website) <http://www.best-price.com/>

Three local stores (or chains) carrying good optical quality binoculars and/or telescopes:

The Wildlife Authority, off Route 40 west of Route 29, look them up in internet for directions

Wild Birds Unlimited – a chain, two or three stores in the Baltimore metro area

Wild Bird Center – a chain, at least one store in our area, off Padonia Road off I-83 north of the Beltway.

Magazine articles with binocular comparison reviews which I used for this article:

the first group of articles following are my main reference sources:

Living Bird Magazine: Cornell review article, fall/winter 2013
<http://www.allaboutbirds.org/page.aspx?pid=2674>

Bird Watchers Digest High-End review published May/June 2012
<http://www.birdwatching.com/optics/2012highendbins/review.html>

Bird Watchers Digest Mid-Price reviews published Jan/Feb 2012
<http://www.birdwatching.com/optics/2011midpricebins/review.html> all 8x
<http://birdwatching.com/optics/2010midsizebins/index.html> 8x32 (approx)

still earlier reference sources:

| | |
|---|------|
| Bird Watchers Digest Mid-Price review published | 2007 |
| Cornell "High-Price" | 2005 |
| Cornell "Economy and Mid-Price" | 2005 |

less-used sources, not much information:

Birder's World 8x32 thru 8x36 models Feb 2010
odd ball collection

toptenreviews.com "Best Binocular Comparisons and Reviews 2013"
this one wasn't a bird watcher magazine article
and didn't have much overlap with the others

SPOTTING TELESCOPES

Spotting 'scopes aren't as easily identified into their classes. I do recommend finding one with waterproofing, same with binoculars. None of my earlier, non-waterproof telescopes or premium binoculars work any more. Both of my current binoculars are waterproof, as is my telescope, and I will no longer buy one that isn't. Fortunately, most of the mid-grade and premium-grade binoculars and spotting telescopes sold today are sealed and waterproof, protecting the investment in the expensive optics.

Spotting 'scopes have higher magnification in order to make out smaller details on more distant objects. This makes a higher demand on the lenses, and **lens types here really are critical**. The basic design features, including coatings and fancier lenses, influence spotting telescope price and optical performance the same way they do with binoculars. The prices are a higher than with the binoculars, but not by a huge amount. A **cheap** telescope will be similar to a cheap pair of binoculars, only **much worse** – with the higher magnification, the **optical flaws** stand out more clearly and it's harder to make out the finer details on more distant birds; you won't be able to see much through a cheap 'scope, and may even see more details with your binoculars. It gets more important to invest in a costlier 'scope which will reveal more details on distant birds, since that's what the 'scope is for. My Alpen 788, \$415 (Amazon), and the Nikon Prostaff, \$600, both have mid-grade 2-element Achromatic lenses (2 + 2) and are good for viewing birds out to about 50 - 75 yards distance. At that range, they get an image which usually seems as good as the top-grade 'scopes. Beyond that, one needs to spend more. The Bird Watchers Digest article in 2009 recommends the Vortex Viper, about \$900, then the Vortex Razor, about \$1,600 at Eagle Optics, and then for even more distant or smaller details, step up to the top-of-the-line elite models by Swarovski, Leica, Nikon (Fieldscope), Zeiss, and Kowa, costing about \$2,600 to \$4,000 (Eagle Optics, Adorama, sportoptics.com prices). Both 65mm and 80mm lens models are popular, but the 80mm models usually have higher magnification available. Scores suggest there *MIGHT* be a tiny optical advantage with the Swarovski and Kowa models. That's a matter of opinion among the reviewers.

Purchasing these high-end 'scopes is a bit more complicated – one usually buys a 'scope body (with objective lens) and separately buys the eyepiece to go with it.

The majority of users find the zoom eyepiece, with variable magnification, to be very useful and prefer to buy their 'scopes with one. However, some purists prefer instead to purchase fixed-power eyepieces, which do offer slightly higher resolution. I do use a zoom eyepiece myself, finding it easier to search through a flock at lower magnification, then zoom in on a particular bird of interest.

For spotting 'scopes, I've found three studies dated 2007, 2009 and 2010, with almost no overlap for models of mid-priced 'scopes covered. I found the Bird Watchers Digest article from 2009 to be most helpful, and used it to choose the 'scope I'm currently using.

**** REPRISE AND OVERVIEW ****

I've owned and used binoculars at all three major grades, and been satisfied with each. Having experienced them all, I do prefer the clearer, sharper images of the higher-grade models when I can afford them.

Another perspective: expensive optics are a long-term investment. For the price of a used car, one could splurge and get top-of-the-line binoculars and telescope, and have money left over for a trip or two to exotic location(s) for exotic birds. The optical equipment will, with reasonable care, last much longer than a new car will. If you expect to be using your optics a lot over the next 20 years or more, the pleasure they give you over that time should justify the expense of getting the best you can afford.

Stay tuned; I'll periodically update this article on the club web page. I can also be reached at pete_webb@juno.com with any questions, comments, or corrections you might like to make.

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internet binocular best price sellers:

Adorama <http://www.adorama.com/>

- often has the best price, but always compare price with Amazon

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Eagle Optics <http://www.eagleoptics.com/> - generally not as deeply discounted, but several models come at Eagle prices exclusively, and exclusively through Eagle.

Best-Price (a price comparison website) <http://www.best-price.com/>

Three local stores (or chains) carrying good optical quality binoculars and/or telescopes:

The Wildlife Authority, off Route 40 west of Route 29, look them up in internet for directions

Wild Birds Unlimited – a chain, two or three stores in the Baltimore metro area

Wild Bird Center – a chain, at least one store in our area, off Padonia Road off I-83 north of the Beltway

REPRISE, NOTES AND WRAP-UP

My experience - I've used economy, mid-grade and premium binoculars at times in my life, and was content with each grade, but always liked the higher grades, when experienced, more than the lower ones. Fairly noticable upgrade in image sharpness and clarity from economy to mid-grade, more subtle but still distinct going up to ED, and again up to premium (tough light or tiny details, reading very distant signs or book text). I have not compared premium with elite-grade (fluoride-lens) binoculars; I'm taking the advice of the Cornell reviewers here. The additional detail definition presumably is so tiny that the human eye can barely perceive it, mostly as a slight enhancement in color intensity. With 'Scopes, the higher magnification makes the differences more visible, especially with small, distant details. Here I would not hesitate to recommend the top-performing 'scopes; they will bring out visible details that lesser 'scopes just can't deliver.

- notes on astronomy / star gazing

In astronomy - looking through 8x or 10x binoculars, especially with the moving image in hand-held binoculars, no matter how good the binoculars actually are, my eyes can't resolve details as

small as Saturn's rings or the two gray bands across the face of Jupiter, however sharply they might actually be resolved by the binoculars themselves. Saturn's rings and Jupiter's gray bands are easily visible but slightly blurry in my Alpen 'scope (on a tripod), at magnifications of 20x or higher. The elite top-of-the-line 'scopes will make Saturn's rings or Jupiter's bands look much sharper and clearer.

When viewing stars or a fuzzy object like a comet, optics with larger objective lenses bring a distinct advantage - with the wider exit pupil, your eyes' pupils, expanded in the darkness of night, can take in more light, so faint but diffuse objects will be brighter than with optics of lesser exit pupil. Of course, there's a limit - my eyes' pupils probably won't dilate more than about 5mm, so optics with more exit pupil than my eyes' actual pupil size won't get all of that light into my eyes. So for me, 8x40 (or 8x42) or 10x50 binoculars will bring in all the light my eyes can take in. When I was younger, and my eyes' pupils could expand to 7mm or more, a pair of 7x50 binoculars would have made the stars a bit brighter. A bright object like the moon (even during lunar eclipse), Jupiter or Saturn will be bright enough that the reduced exit pupil of a spotting 'scope wouldn't matter much at all, while for comet viewing, the binoculars, with a wider exit pupil, are a much better choice. And something like the aurora, if the opportunity should come along, would be best seen without optical magnification, for the wider field of view of unaided eyes. Same with meteor showers. But to get the colors in auroras, nebulas or the Andromeda galaxy, as seen in photographs, one needs long-exposure film or optical sensors, not real-time viewing by eye, with or without optics. Andromeda will just be a faint blur, which is actually just the brightest portion near the center of that galaxy.

And to see any detail on Mars, or more than just the two gray bands on the face of Jupiter, one needs a true astronomical telescope, with much higher magnification and a motor-mount to keep the 'scope tracking as the earth rotates the sky above us. Of course, those come with a price tag.

And that specialized equipment is not for bird watching.

Recommendations for bird watchers – the 7x35 porro prism binoculars are best for most people, especially casual users, beginners, or visitors.

Only experienced and skilled users will benefit from the higher-powered 8x or 10x binoculars. Those wanting the higher-powered binoculars and the 'scopes will find the higher-classed optics with the fancier lenses rewarding in improved viewing, but can still benefit from the less expensive classes; they are distinctly better than nothing, if chosen well.

But yet another perspective – the expensive optics are a long-term investment in viewing pleasure. For about the cost of a used car, one could splurge and buy state-of-the-art, top-of-the-line binoculars and telescope and have money left over for a trip or two to exotic places to see exotic birds. And with reasonable care, the optics should last much longer than a new car would.