2007 Study Update, Part 6

By
Dr. Ed Ashby

Current broadhead testing

Abowyer Custom, 190 grain

Testing of the 190 grain Abowyer presented a most perplexing outcome. For testing this left single-beveled broadhead was mounted on left fletched, Internally Footed (IF) Extreme FOC shafts, having a total mass of 810 grains.

Only 3 test shots were taken with this setup. All were broadside back of the shoulder impacts on a large buffalo bull, from 20 yards. The first shot penetrated normally, passing through the rib for a double lung hit. Penetration was 16 inches. Not an unexpected outcome, considering the big Abowyer's great width and lower mechanical advantage (MA).

The surprise came on the next two shots. Both skidded *violently* off the modestly curved surface of the buffalo's rib; an event distinctly observable (see photo, below). Neither penetrated the rib. Penetration was 4.25" and 5.125". One of the broadheads suffered a severely rolled edge (see photo); quite a testimony to the hardness of buffalo ribs, considering the Abowyer's relatively high Rockwell Hardness. This is the first rolled edge encountered with an Abowyer, and is suggestive that a single-bevel's steel hardness needs to be greater the lower the broadhead's MA. The Internally Footed shafts came through the two violent impacts undamaged, providing another indicator the IF design works well in preventing carbon shaft damage.

The three test shots with the 190 gr. Abowyer Custom. All were fired from 20 yards, with no change in shooting position. The deviation on impact on the two bone-skids was violent, and profoundly noticeable.

Damaged edge on the 190 gr. Abowyer, *suggesting* the need for greater steel hardness as broadhead MA becomes less. Note the direction of edge roll; opposite the direction of the bevel-induced broadhead rotation. Also note the removed finish and surface scratches on the broadhead's face. This was the first shot on a brand-new broadhead. No doubt buffalo ribs qualify as hard bone!

The 125 grain Abowyer was tested previously. From all acceptable shooting angles (broadside to plus-minus 25 degrees) it rendered outstanding performance. It was anticipated the 190 gr. Abowyer would prove an effective wide-cut broadhead for moderately heavy game but, clearly, something is amiss to cause these broadside-impact skips.

This skip-tendency would be of lesser consequence, and less readily noticed, on an open-ribbed animal. There, on a broadside shot the broadhead would have skidded from the rib and entered at the first intercostal gap. With a configuration matching the one tested, the results do not bode well for shots angularly impacting scapula, leg, hip or spine on all but very lightly built animals. The immediate question became, "What caused this to occur".

First suspicion fell upon arrow flight. As with all test arrows, this setup had been previously checked for quality of flight. However, the first order of investigation was to retest the arrow setup.

After photographing the rolled edge, the 3 arrows were thoroughly cleaned, dried and inspected. Broadhead alignment was checked. All showed true alignment. They were then fired into the broadhead target from 20 yards. This was repeated four times. All showed straight flight, impact and penetration; even the one with a rolled-edge.

All shafts were again cleaned and checked for damage. Fletching was removed from two of the shafts and the broadheads were replaced with 190 grain field points. Bare-shaft testing at 20 yards showed perfect flight, with the un-fletched shaft's impact matching the fletched (broadhead tipped) shaft. The problem did not lie with arrow flight.

The following is a start at trying to determining how broadhead dimensions might have affected the angle of skip. All testing has indicated that skip-angle rapidly becomes worse as broadhead width increases, in relation to length. This reflects the blade's angle of attack to the bone's surface at the instant of contact and during penetration.

The two Abowyer broadheads that have been tested, and as tested (tips modified to a COI Tanto), have the following pertinent dimensions:

A. 125 Grain: Over all length (OAL): 1.925; Cut Width: 1.108"; Angle of main-blade attack (cutting angle): 14.2 degrees. Attack angle of Tanto tip: 30 degrees. Blade Thickness: 0.065"

B. 190 Grain: OAL: 2.361"; Cut Width: 1.371"; Angle of main-blade attack: 14.6 degrees. Attack angle of Tanto tip: 37 degrees. Blade Thickness: 0.065". (Thickness of both the 125 gr. and 190 gr. was measured without blade finish, as it had been worn off all the 125 gr. samples during their testing, and stripped-away on each 190 grain's first shot.)

For comparison purposes, here are the dimensions for the 190 gr. Grizzly, Modified Grizzly and Grizzly Extreme. These have all demonstrated excellent skip-angle, with the Grizzly Extreme showing the best skip-angle of any broadhead tested.

C. Grizzly 190 grain, freshly sharpened and tip modified to COI Tanto: OAL: 3.135"; Cut Width: 1.125"; Angle of blade attack: 9.0 degrees. Attack angle of Tanto tip: 30 degrees (the factory Tanto profile is at about 40 degrees). Blade Thickness: 0.057".

D. Modified Grizzly: OAL: 3.135; Cut Width: 1.0"; Cutting angle (angle of Attack): 7.4 degrees. Attack angle of Tanto tip: 30 degrees. Blade Thickness: 0.057".

E. Grizzly Extreme: OAL: 3.135; Cut Width: 0.6875"; Cutting angle (angle of Attack): 4.85 degrees. Attack angle of Tanto tip: 30 degrees. Blade Thickness: 0.057"

There are many differences between the 190 gr. Abowyer and the Grizzly broadheads, as expected considering the vastly different profiles. One difference, however, is potentially pertinent. The 190 gr. Abowyer measures a much greater angle of attack on the Tanto tip. While the 190 grain Abowyer's main-blade angle of attack is greater than the Grizzly and its derivatives, it is only 0.4 degrees greater than that of the 125 gr. Abowyer.

Higher MA broadheads (long, narrow ones) consistently show a much better skip-angle than shorter-wider broadheads. Broadheads such as the Zwickey Delta, Magnus I or Snuffer (or Muzzy, G5 Montec and Ultimate Steel) show poor skip-angles;

skidding off bone about 50% of the time when the impact-angle is 35 degrees.

The hunter must keep skip-angle in mind when using any broadhead having low length-to-width ratio. Avoid shots where potential bone impact is likely to be at a steep angle. This includes adverse-angle impacts with light bone (rib). Poor impact-angle rib hits are a common feature encounter by the tree-dwelling archer. I suspect that many non-recovered tree-stand 'pass-through hits' are, in reality, an arrow that skipped off the ribs (or other bone), giving only a superficial flesh wound; but terrestrial bowhunters also need to consider skip-angle.

Curtis Kellar (who graciously does adjunct testing for the Study, for which I'm eternally grateful) reported a from-the-ground skip with the 125 gr. Abowyer. It was a long-angle quartering shot, and the broadhead skipped off a rib, "Opening the skin up like a zipper, all the way down his side". This was not on an over-size big game animal; it was a feral goat.

Considering the Abowyer's blade-angle, bone-skip is the *likely outcome* at any impact angle greater than 35 degrees. Incidentally, the goat was recovered, but not as a result of that shot. However, Curtis was able to verify that the skip was, indeed, off the lightly-constructed rib. A huge 'attaboy' award goes to Curtis for his persistence and fine follow-up.

In tip-testing the Tanto profile showed the lowest skip-tendency. Could the tip angle of the big Abowyer have initiated the skid? It is more abrupt than any tip angle used during skip-testing.

Measurements were taken for the Tanto tip's angle of attack on many previously modified and tested broadheads. It was apparent the tip I apply becomes more abrupt as the length-to-width ratio becomes less. The greatest angle of tip attack previously used - 57^0 - was found on the 160 gr. Wolverine, and was intentionally applied that way.

Unmodified, the Wolverine showed a marked tendency to shatter the factory tip all the way back to the edge of the ferule's overlay. Stopping this required modifying the tip to a very wide and steep Tanto profile (because of the positioning of the ferrule overlay).

F. Here are the dimensions for the modified Wolverine, as tested: OAL: 2.140; Cut Width: 1.140"; Cutting angle (*approximate average* angle of attack of the convex blade – 'estimate' measured with a protractor and straight edge): approximately 12 degrees. Attack angle of Tanto tip: 57 degrees. Blade Thickness: 0.037"

The 125 and 190 grain Abowyer broadheads and the Wolverine (R)

Next, a look was taken at the Magnus I ('Delta' profile), as modified (Tanto tip) and tested.

G. The Magnus I has an OAL of 2.143"; Cut width is 1.394". Main-blade attack angle is 17 degrees. Tanto tip's attack angle: 53 degrees. Blade Thickness (at tip): 0.065".

Comparing the Wolverine and Magnus I to the large Abowyer shows both have a more acute angle of tip attack, yet neither had shown greater than expected skip tendency for broadheads of their dimensions. The Abowyer shows a steeper angle of main blade attack than does the Wolverine, but the shorter-wider Magnus I has greater angles of attack on both the main-blade and Tanto tip. The Magnus I has the same tip thickness the Abowyer.

Taking a closer look at the Tanto tips on the 125 and 190 gr. Abowyer shows a couple of differences. The blade's width *at the rear edge* of the 125 gr. Abowyer's Tanto tip is 0.171". It is located 0.152" back of the tip. On the 190 gr. version the blade width at the Tanto tip's rear edge is 0.205", and is located 0.185" behind the tip. The Wolverine's Tanto has a 0.238" width, located 0.089" rearward of the tip, while that on the Magnus I measures 0.20" wide, and is 0.145" back of the tip.

Because of the greater blade width at the 190 gr. Abowyer's Tanto tip rear terminus, its tip must penetrate somewhat deeper than the others before the main blade enters the bone's structure, and would have to excavate a wider cavity than all except the Wolverine (but the Wolverine also has the thinnest blade and requires the least penetration of this group in order for the main blade to gain bone-purchase).

These may sound like insignificant differences, but that *may* not be the case.

Another difference is that the Tanto tip is reverse beveled on the single-bevel heads and double-beveled on the other broadheads shown. A reverse-bevel on the Tanto tip *appears* to offer a slight advantage on the Grizzly, but that *may* not hold for the much larger Tanto tip on the big 190 Abowyer.

The 125 grain Abowyer is among the top performing broadheads in buffalo testing, when used within the recommended shooting angles. There are only modest profile differences between the 125 gr. and 190 gr. Abowyer broadheads. Why the vast difference in skip tendency? The above is *suggestive* that the problem encountered lies somewhere within the combination of the steep angle of attack of the Tanto tip, the width and depth of the tip, and the steep attack-angle of the main blade; or with the tip's bevel-type.

It is my *conjecture* that: (1) A higher mechanical advantage on the Tanto tip (a longer-narrower tip profile with a better angle of attack) *might* permit the 190 gr. Abowyer to achieve deeper tip penetration into the bone, thus providing greater purchase of the broadhead into the bone, making it less likely the broadhead will lose its grip upon the bone's surface. (2) Conversely, making the Tanto tip's profile even more abrupt; as that on the Wolverine and Magnus 2; *might* require less depth of bone penetration prior to the main blade gaining purchase upon the bone. (3) Double-beveling the tip might achieve better bone penetration. (4) Some combination of the above changes to the Tanto on this very wide broadhead may be required to reduce this marked skip tendency.

Regardless of cause, results warrant further testing with different tip modifications. It certainly appears that it is something about the tip's configuration that's causing the problem, and that presents a golden opportunity to learn a bit more about how a tip's design may affect penetration. Who knows, cracking this problem might show a way to improve a broadhead's ability to obtain bone-purchase on angling impacts, offering some improvement in broadhead skip angle; and perhaps even some penetration increase on other, more perpendicular bone impacts.

For heavier game the 125 grain Abowyer remains a top choice, as long as you remain cognizant of the shooting-angle limitations its blade-angle implies. There are several weights available between the 125 gr. and the 190 grain, but none have been tested.

More broadhead design features to consider

Much discussion has been directed towards mechanical advantage and the increased penetration-potential offered by long-narrow broadheads. The above exercise brings up other aspects of broadhead design few bowhunter's think about … but should.

The longer a broadhead's cutting edge, the greater distance every point of tissue touched travels along the edge. Increased tissue-travel distance along the edge increases contact time, offering the blade greater opportunity to sever any vessel touched.

To see the difference longer contact time makes, place the edge of a sheet of paper against a sharp knife's blade edge. Keeping even pressure of paper to blade, push or pull the paper along the blade. The greater distance the paper is moved, the more deeply it is sliced. What you're observing is *increased cutting potential resulting from greater travel-distance*. With broadheads, longer edge-length increases the likelihood blood vessels encountering the blade's edge will be severed.

Why the "Keeping even pressure of paper to blade" qualifier? A broadhead acts as a compound-wedge during penetration. Blade width and thickness, ferrule-taper and edge-bevel all spread tissues at an angle to the blade's edge. This tensions pliable tissues against the edge. Bevel-induced broadhead rotation also creates a tissue-tensioning effect, increasing cut-efficiency. It *might* also cause tissues to be dragged forcefully across the blade's sharp edge, as the blade rotates.

And there is more. The angle of attack of the blade to the tissues affects the type of cut achieved. Consider a Chinese cleaver. It is a very sharp, thin bladed kitchen cutting-instrument that resembles the rear 3/2 of a *huge* French Chef's Knife (see photo). Though it can be used as a *light duty* chopping tool, its primary function is as an ultra-high-efficiency slicing tool. Up-market versions have a prominent hollow grind, only slightly less pronounced than that found on straight-edge razors. This gives an exceedingly thin cutting edge. Properly sharpened, they cut like a giant-size straight-razor too.

Applied with hefty force the Chinese cleaver shears soft flesh well, but examine the cut. Despite the very thin and sharp edge, it is a 'crushing cut' rather than a slice. If the cleaver is placed flat upon the meat and drawn (or pushed) across, it slices through tissue almost effortlessly, producing a smooth, clean cut. Place the blade at any angle in between and it cuts with more effort and less efficiency than when flat on the meat. The ease and speed with which they produce slicing cuts is a main reason Chinese cleavers (and/or the large French Chef's Knives) are so popular with professional chefs.

Chinese Cleaver (Shown with 8" blade French Chef's knife). Note the marked hollow-grind on this cleaver's blade; it gives a thinner cutting-edge than would a straight-bevel of equal width.

For those who don't spend much time in culinary pursuits, perhaps a more common experience showing the advantage of a *long* sharp cutting edge *at a low angle of attack* would be simply cutting a beef steak at the dinner table. Even with a sharp knife, some cooked steak is tough to slice through.

When you encounter a tough steak, what do you do? Do you take your knife and chop away at it, using straight down blows? Do you elevate the knife's handle to increase the blade's angle of attack, decreasing blade to meat contact? Do you drop the knife's blade to lower the cutting edge's angle of attack across the meat and take longer cutting strokes; increasing tissue contact with the cutting edge? Perhaps you merely increase cutting pressure, using increased force to compensate for inefficient cutting action.

At your next steak dinner give each method a try, *using a truly sharp steak knife* at even cut-pressure. At the same degree of sharpness and pressure, which allows you to cut through a tough steak with the least effort? These little-observed everyday events point out some advantages you gain through use of long-narrow broadheads. You gain a better angle of blade attack upon the tissue and longer tissue-travel along the cutting edge; ergo, a more efficient, cleaner, faster, and decidedly more lethal *slicing action … and* you gain more arrow penetration too! We want our broadheads to create the most efficient degree of hemorrhage. Blood vessels cut with a smooth sharp edge bleed more freely.

At about this point someone is going to say, "My serrated stake knives cut stake better than my straight edge ones, so why not use serrated edge broadheads."

There are several reasons why serrated edge steak knives are widely used, and often *seem* to cut our mealtime beefsteaks with more ease than the straight-edged ones commonly encountered. The chief reason is that not many folks have steak knives with high quality steel, and even the few who do (at least among those I've encountered) don't keep them well sharpened. The other factors all revolve around the steak on our plate already being dead, butchered and cooked.

Our dinner steak doesn't have a covering of fibrous skin; and the fibrous connective tissue remaining in the steak has been modified by cooking. As our early ancestors all knew, cooking connective tissue - skin, sinew, horn or hoof - softens it. Cook it long enough and it becomes liquid, making good glue.

Slicing tissues requires a very sharp edge. If a smooth edge is not sharp, it has great difficulty cutting through even soft tissues; it has to tear them, rather than slicing through them. Even when dull, a serrated edge has a rough, irregular and abrasive edge. This makes it easier for the edge to tear at the tissues; but not easier for it to *cut* tissues.

Most crucially, in living tissues there are bones our arrow must cut or break. Arrows can't neatly carve around bones, as we do when eating our steak. Bone is the most difficult tissue your hunting arrow will be called upon to deal with, and bone contact occurs on the vast majority of hits. Bone doesn't *cut* well with anything short of an offset-tooth saw blade.

Whenever a full-on bone impact situation arises; and it will; to effectively reach vital areas our broadhead must either penetrate the bone, smashing its way through, or split the bone. Either of those options of dealing with direct bone impacts requires a lot of force. Even at their best, arrows have little excess force to spare. We need to use our arrow's sparse force as effectively as possible.

A serrated edge's tiny projections are fragile. They are easily damaged by hard bone. Once damaged they cause markedly increased resistance to penetration. This dramatically increases arrow drag. Having serrations on the cutting edge also reduces the broadhead's mechanical efficiency; its ability to use whatever amount of force it carries. Serrations cause increased resistance.

For elevating a resistance load (which is what a broadhead does as it penetrates) a very smooth and gradually inclining plane does the most work with the least outlay of applied force. That's why wheel chair ramps are a straight incline – and why they don't have 'speed bumps'. If a load could be raised to the same level with less force by using a concave or convex wheel chair ramp, or one that had periodically raised ridges on its surface, you can bet they would be made in that shape!

Need more proof? Drop by the local butchery and see how many serrated knives these folk who make their livelihood slicing through tissues have on hand. Serrated edges do not *cut* tissues as well as a smooth sharp edge – but they will *tear* through tissues better than a dull smooth edge.

And about here someone is going to say, "But the knapped edge of a flint broadhead is a serrated edge, and everyone agrees they 'cut better' than a steel broadhead". Few edges cut more efficiently than the ultra-thin edge obtained by removing a flake from flint or obsidian; but one that does can be found on *smoothly polished* obsidian scalpel blades, which, in pre-laser days, were often used during delicate eye surgery.

An obsidian scalpel cuts more cleanly than any steel blade, and cleaner than even the finest obsidian flake. Why? That's because its edge has absolutely *no serrations*. Its cut is fully as smooth and flawless as that of a surgical laser, but the laser's advantages of pinpoint focus and simultaneous cauterization of cut vessels has antiquated the obsidian scalpel.

The above is merely additional food for thought. In our next Update we'll cover a bit on how to measure a blade's angle of attack and begin discussion of the other current broadhead testing.

