2008 Study Update, Part 7

By
Dr. Ed Ashby

First, I must apologize for the long delay in posting this portion of the Updates. Events beyond my control prevented its timely completion.

Up to this point the 2008 Updates have been devoted to the Heavy Bone Threshold testing and the effects of arrow FOC on terminal arrow performance. At the close of the Part 6 Update it was stated that Part 7 would be devoted to how you can apply the Study's information to your own arrow setup. As I began work on this Update I realized that I had failed to discuss the results of other test conducted during the 2008 testing. As some of this information is pertinent to arrow setup it is necessary to cover this information prior to discussing applying the Study's information to your own setup.

Ultra-EFOC and Arrow Shaft Structural Integrity

In previous testing with Normal, High and EFOC arrows there has been high damage rate to synthetic shafts. That high damage rate led to development of the Internal Footing (IF). You may have noticed that IF's were not used on the Ultra-EFOC arrows, yet there has been no reference to the shaft damage rate. That's because no shafts were damaged during the Ultra-EFOC test series. This was not much of a surprise with the below threshold, 620 grain Ultra-EFOC from the 40# recurve. Because of the lower impact force the peak resistance force encountered by arrows from the 40# bow is much lower than that encountered with the more forceful arrows from the heavier bows. Less arrow impact force places less stress on the arrow's component parts.

When it came to testing the 655 grain Ultra-EFOC arrows from the 64# ACS-CX and 82# longbow this lower impact force was no longer the case. Previous arrow setups tested from these higher draw weight bows; whether of below or above threshold weight and whether of Normal, High or Extreme FOC; have all shown a relatively high damage rate for non-reinforced (non-internally footed) carbon shafts.

The just above-threshold Ultra-EFOC arrow used with the 64# ACS-CX and 82# longbows has a shaft wall that is significantly thinner than any of the shafts previously tested from the heavier draw weight bows; a mere 0.0245". A damage rate higher than that observed for other non-reinforce carbon shafts was anticipated, but this was not the case. The only logical explanation lies in the lower weight of the trailing shaft. In developing Ultra-EFOC arrows, especially at a modest amount of total arrow weight, it is necessary to use the very lightest weight shaft that can be made to work, concentrating all remaining weight as far forward as possible.

On the surface it would appear that any arrow of a specific weight impacting a heavy bone at any given level of force would encounter the same level of peak resistance, but this is not the case. A number of the arrow's design features affects the peak level of resistance encountered. Broadhead design is a big factor, with the broadhead's profile – the 'smoothness' of its shape – and its mechanical advantage both lowering the peak level of resistance. The broadhead's edge design is another big factor. Bevel testing has definitively shown that a single-bevel design splits bone more easily than a double-bevel edge design, and significantly reduces the shaft damage rate (See "Arrow Integrity Implications from the 54# Bow's Testing", 2007 Update, Part 3).

Broadhead design could not, however, be the shaft-saving factor for the Ultra-EFOC arrow. All EFOC testing with the 54# and 70# bows has been with the 190 grain Grizzly; the same broadhead used in testing these Ultra-EFOC arrows. The shaft damage rate for the 54# bow's non-reinforced (non-IF) EFOC arrows is 12.5%. For the 70# bow that rate is 11.1%. When the decidedly stronger Grizzly Stik shafts are eliminated from the mix, the 82# bow's damage rate for non-reinforced carbon shafts with the Grizzly broadhead is 16.7%. A damage rate at least that high was expected for the Ultra-EFOC arrow's thinner walled shaft, but it did not happen.

The shaft damage rate for the Ultra-EFOC arrows is *suggestive* that reducing the mass-weight of the shaft is a mitigating factor in shaft damage, <u>at least on direct impact hits</u>. Think of it this way. As the front of the arrow abruptly decelerates at impact the arrow's rear continues to push forward. This creates a 'crushing force' between the shaft; which is still trying to move forward; and the arrow's tip, which has abruptly slowed. The heavier the arrow's rear section the greater its forward *inertia*; therefore, the greater the 'crushing force' exerted on the shaft.

Inertia is the tendency of a body in motion to remain in motion (or of a body at rest to remain at rest), unless acted upon by an outside force. On impact the arrow's forward inertia encounters an outside force which abruptly decelerates it. As the arrow's front abruptly slows the shaft's inertia keeps pushing forward. In the absence of continuing penetration (at a rate equaling arrow velocity) this clash of opposing forces means the shaft's forward inertia must either: (1) compress the shaft linearly; (2) fracture the shaft, or; (3) be dissipated by shaft flex. Synthetic shafts show very little linear compression. If the bond between insert and shaft-wall is sufficiently strong to resist the force of the inertial impulse the insert won't be driven into the shaft, splitting it. However, a shaft will only flex so far before fracturing at the point of greatest stress, which is located where the rearward portion of the non-flexing insert meets the hollow shaft.

There are only 2 ways to reduce these shaft-damage tendencies. (1) At the junction of insert and shaft, support the bond between insert and shaft *and* spread the flexion force across a longer portion of the shaft. This is what the IF does. (2) Reduce the level of inertial force from the arrow's rear; and this is what the Ultra-EFOC arrows have done by reducing the weight of the shaft.

If you have trouble visualizing the effect of these opposing forces; inertia and resistance; try this. While holding a basketball in your hands and riding as a passenger in a car traveling 30 miles an hour (a mere 44 feet/second) have the driver do a 'panic stop' (be sure you have your seat belt on, too). Now repeat this exercise while holding a bowling ball. Inertia's effect, and the difference mass-weight makes during deceleration will instantly become very clear!

Now think of the front of the car as representing the broadhead and the basketball and bowling ball as representing the shaft's rear mass. The force exerted on your hands during deceleration would represent the shaft's inertial impulse; the impulsion force (forward impetus) exerted on the shaft. Though the resistance force (which is what has caused the deceleration of the car) will be the same in each of these cases, the heavier bowling ball's inertial impulse exerts more forward force than does the lighter basketball. Note: during this exercise do not hold the bowling ball at windshield level … and keep your feet and toes well out of the way!

The lower inertial mass of these Ultra-EFOC shafts also means that there will be less total shaft flex at impact. Shaft flex has been shown to be a major factor in arrow penetration. This is easily demonstrated. Using a well tuned arrow having Normal FOC shoot several arrows into a new foam target at very close range, say 2 or 3 feet, and measure the average penetration. Now shoot those same arrows into the same target at 15 or 16 yards. Though they will have lost some velocity (and force) the arrows shot at the longer range will show greater penetration. This is because the Normal FOC arrows are still in extreme paradox at the close range; they are flexing to a greater degree than they are at the longer range. The greater shaft flexion increases the resistance to penetration. Their lesser degree of shaft flex at impact is the predominate reason Ultra-EFOC arrows show such an astonishing degree of gain in post-breaching tissue penetration; compared to comparable arrows of Normal, High and Extreme FOC.

Compared to Normal, High and Extreme FOC arrows, on perpendicular impacts there appears to be less need for an IF on the Ultra-EFOC arrows; at least for those with a total mass comparable to the arrow setup tested. What the shaft damage rate for higher total mass Ultra-EFOC arrows, which might well have a greater amount of shaft weight, remains to be determined.

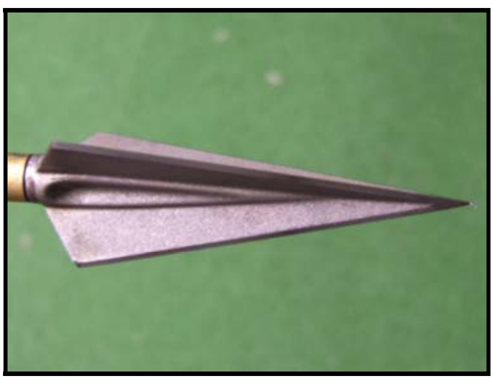
It must be cautioned that no oblique-impact testing has been done with these Ultra-EFOC arrows. Non-perpendicular impact causes increased flexional stress on the shaft. The oblique-impact force vectors combine with the shaft's inertial impulse to act in a non-linear direction to the direction of arrow travel. This means greater total flexional force is placed upon the arrow's shaft than that which is encountered during direct impacts.

The Internal Footing is a well tested and proven method of spreading these flexional forces across a greater portion if the shaft's length, forestalling shaft damage, even on the heaviest of hard-tissue angular impacts. Though I have a preference for the Internal Footing the use of *a graduated set* of External Footings has been shown to achieve the same flexional force distribution along the shaft, working equally well. You can find more information, along with photos, on these External Footings in postings by "Kingwouldbe", in the Ashby Forum at www.tradbow.com.

Now let's take a look at the broadheads tested during 2008.

Broadhead Testing

The 300-Xtreme



For testing, the three-blade 300-Xtreme was mounted on a carefully tuned EFOC shaft. The arrow setup was: Carbon Express Heritage 350 shaft; 100 grain brass insert; Fletching, 2.5" A&A

pattern four fletch; mass 796.5 grains; FOC 26.2%; Impact Force, 0.527 Slug-Feet/Second. Testing was conducted with the high performance 64# ACS-CX longbow. It should be remembered that, with arrows of equal mass this bow has been shown to produces arrow velocities equaling that of the straight-end, 82# longbow used in testing. Four test shots were taken with this setup. All shots were from 20 yards and at a broadside shooting angle. All shots had well placed thorax impacts.

Two shots were taken on a trophy class Asian buffalo bull. The first shot failed to penetrate the entrance rib, and gave a penetration of 5 inches. The second shot barely penetrated the rib, giving 7.625 inches of penetration.

The second two shots were taken on an adult male Asian buffalo of significantly smaller size than the trophy bull. The first shot failed to penetrate the on-side rib, giving 4.625 inches of penetration. The second shot successfully breached the entrance rib, penetrating to the off-side rib. It gave a total penetration of 18.375 inches.

While the 300-Xtreme held up well, structurally, only one of the 4 shots managed to penetrate the entrance rib. Based on the test results with other, similar profile 3-blade broadheads better penetration was anticipated from the 300-Xtreme; especially since it was mounted on a fairly heavy, EFOC arrow setup. These results, however, do present a dramatic example of the increased difficulty all 3-blade broadheads have in penetrating heavy bone. It should be remembered that in all test results, dating all the way back to the original Natal Study, three blade broadheads have shown the poorest heavy-bone penetration ability of all broadhead designs, ranking well behind 4 blade broadheads and substantially behind single blade broadheads.

Broadhead "Ratio" vs. Mechanical Advantage: A Word of Caution

In several write ups of the 300-Xtreme I have seen this broadhead referred to as being a "3 to 1 ratio" broadhead, and it is not the only 3-blade broadhead frequently referred to as having a "3 to 1 ratio". **This statement can be very misleading, causing many to think that these 3-blade broadheads have the same Mechanical Advantage (MA) as the 'classical' "3 to 1 ratio" single-blade broadhead.**

It was Howard Hill who first popularized the term "3 to 1 ratio", as applied to broadheads. Indeed, it is likely that Howard is the person who coined the term. The cutting blade of the Howard Hill single-blade was (and still is) 1" wide, with a 3" long cutting edge. The cutting blade of Howard's favorite broadhead not only has a "3 to 1 ratio", it has a Theoretical

Mechanical Advantage very near 3.0 (and would be 3.0, were the cutting edges not of a concave profile).

Confusion arises about the term "3 to 1 ratio" because folks are now using various definitions about what "3 to 1 ratio" implies, and how it is measured. That's the very reason the Study uses the more precise, scientifically defined term "Mechanical Advantage". Let's see if we can clear up this difference in terminology.

Mechanical advantage (MA) is the upper hand you gain when you use a mechanical device or machine to help you multiply the amount of *FORCE* you can transmit. In physics and engineering MA is the *factor* by which a machine multiplies the **FORCE** put into it. *It is the **FORCE-AMPLIFYING** effectiveness of a machine*.

The ***Theoretical Mechanical Advantage*** of a system is the ratio of the **FORCE** that performs the useful work to the **FORCE** applied, and assumes that there is no friction in the system. MA is commonly expressed mathematically as a ratio or fraction. The top number of the fraction (or first number of the ratio) is the theoretical **FORCE** the machine *puts out* while performing the work accomplished. This top number is therefore called the **FORCE OUTPUT.** The bottom number of the fraction (or second number of the ratio) is the theoretical **FORCE** you must *put into* the machine to accomplish that work, and is called the **FORCE INPUT.** Note that MA deals with the **FORCE** involved, **NOT** the amount of **ENERGY** involved. In practical application the Theoretical Mechanical Advantage (and the actual MA) are often stated in relation to an input value of 1; thus a MA of 3.0 implies a MA ratio of 3 to 1.

The ***Actual Mechanical Advantage*** of a simple machine is defined as the ratio of the **FORCE** applied to the **USEFUL WORK** actually accomplished. **For all those folks who seem to be hung up in a belief that only precisely repeatable, laboratory based results under strictly controlled conditions represents 'true science', please note that *the actual MA of a machine is measured using Outcome Driven results; the exact same methodology applied to the Study's outcomes of terminal arrow performance. The Actual MA is measured across a number results,* as the machine is used in its actual, intended application of the task at hand; thus taking into consideration all the non-productive force(s) consumed (the many resistance *VARIABLES* encountered) as the machine accomplishes its useful work.** Whenever the Actual MA of a machine is available it is that value that engineers rely upon when applying Mechanical Advantage in a real world situation, not the machine's Theoretical MA.

Just as for a broadhead, the entire arrow system will have an Actual Mechanical Advantage. It's worth noting that, just as for any other simple machine, an arrow's *actual MA* deals with the arrow's *force*, not the arrow's energy, and can be measured only in terms of the actual *outcome results* when tested while performing its intended application in a real world environment. The outcome results will be a function of the resistance of the individual medium(s) against which the arrow must perform its useful work. This is why penetration testing of arrows in artificial mediums can not be successfully used as a predictor of outcomes in fresh, in situ tissue(s).

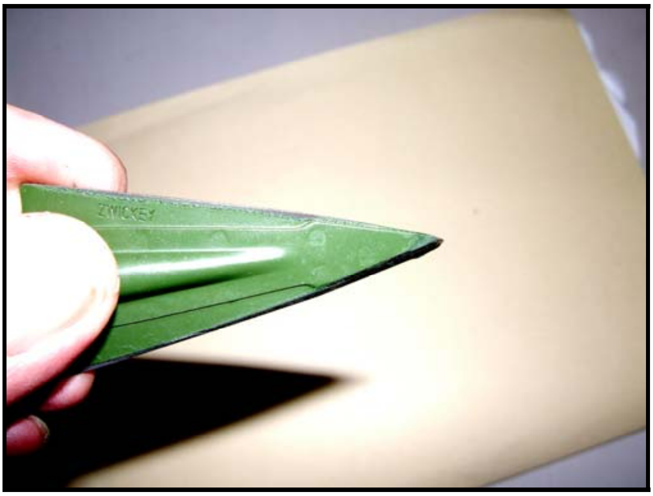
While Howard Hill was very clear in his meaning of a 3 to 1 ratio broadhead, today is seems that a "3 to 1 ratio" means different things to different folks. Nowadays, some folks seem to interpret “3 to 1 ratio” to mean that the height of each cutting blade is 1/3 the length of that individual blade’s cutting edge. For example, they will term a three-blade broadhead where each blade had a cut height of ½” with a cutting edge length of 1.5” a “3 to 1 ratio” broadhead; meaning that the length of the cutting edge of that individual blade is three times that individual blade's cut height. **This gives THAT INDIVIDUAL BLADE a MA of 3.0, but it DOES NOT give the broadhead a MA of 3.0. The calculated MA of such a broadhead is only 1.0!** That’s because the total cut width of the broadhead's three blades; 1.5”; equals the 1.5” length of the broadhead’s cutting edge.

Other folks use a ratio of the 'cut diameter' of a multiblade broadhead to the blade's length as a measure of the 'broadhead ratio'. To determine the 'cut diameter' they scribe a circle around the rear of the cutting blades, then measure the diameter of this circle and use that dimension as the broadhead's 'blade width', comparing it to the blade's length to determine the 'broadhead ratio'.

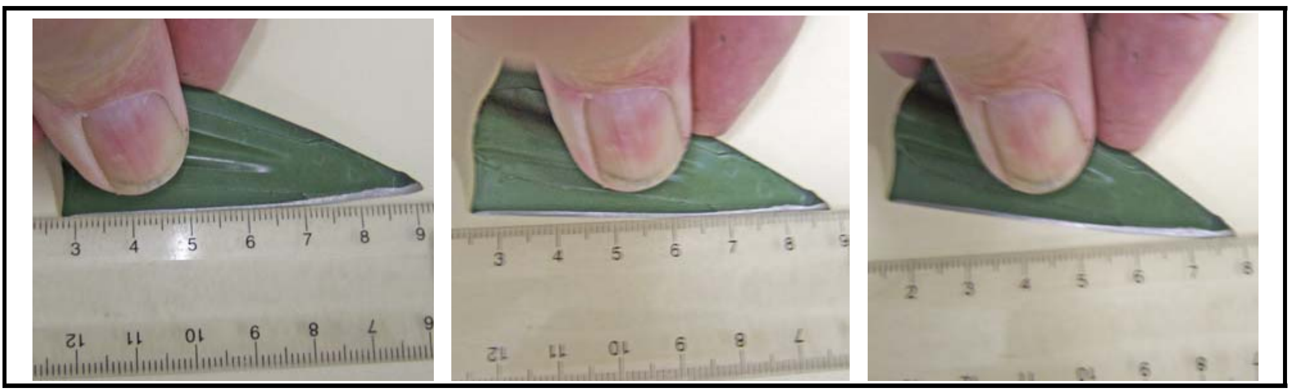
Going back to the 300-Xtreme, regardless of what method anyone used to determine this broadhead's 'ratio' at "3 to 1", its Mechanical Advantage is decidedly not 3.0. The MA of the 300-Xtreme calculates at 1.54; modestly better than the Woodsman's MA of 1.43. In order to have a MA of 3.0 the 300-Xtreme would need to have a blade length of 5 inches! This discrepancy between Mechanical Advantage and the claimed 'ratio' is clearly manifest in the test results.

Not to have any of the forgoing misinterpreted, the 300-Xtreme is, in all probability, the finest 3-blade broadhead tested in the Study to date but, as for every other 3-blade yet tested, it is far from a reliable performer *when heavy bone is impacted*.

The Single-Bevel No Mercy



When the No Mercy single-bevel broadheads ordered for testing arrived, the first thing noticed was that the profile of the blade's edge consisted on three distinct tapers. If you look closely at the photo above you can see changing taper along the broadhead's edge. The following pictures make the distinct tapers more visually obvious.



The main edge's taper is shown in the left hand photo. It extends from the back of the broadhead's cutting edge to the most rearward portion of the triple thick tip overlay. There, as shown in the middle photo, the angle of the cutting edge changes. This new edge angle extends from the rear of the tip overlay to the start of the bevel at the very tip of the broadhead; shown in the right hand photo. As it required sharpening in segments, maintaining this changing contour of the edge profile, while also coping with the change in steel thickness at the tip, made sharpening somewhat of a tedious chore. However, since this changing taper is the factory profile the compound edge contour was maintained during sharpening for testing.

For use on the heaviest of game, the No Mercy's 1.2 inch cut width is wider than optimal for the 2.529 inch cutting edge length. These dimensions give the No Mercy a calculated Mechanical Advantage of 2.11.

For initial testing the 130 grain, right single-bevel No Mercy broadhead was mounted on a well tuned EFOC arrow. The arrow setup was: Cabela's Outfitter 60-75 shaft; 100 grain brass insert; 125 grain steel broadhead adaptor; Fletching, 2.5" A&A pattern four fletch; Total arrow mass 767 grains; FOC, 23.5%; Impact Momentum, .518 Slug-Feet/Second.

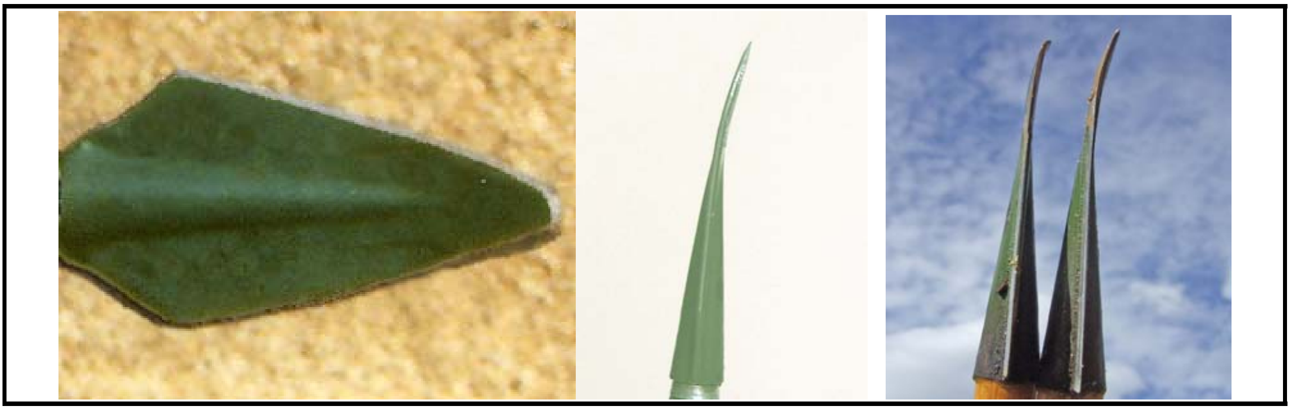
The 82# longbow was used for initial testing of the No Mercy broadheads. Three test shots were taken with this arrow setup. All shots were broadside, at a distance of 20 yards, on a very large trophy class Asian buffalo bull. All shots had thorax impact. The first shot penetrated the entrance rib, traversed the thorax and stuck solidly into the off side rib. Penetration was 20.5 inches. The second shot gave almost identical results, with a penetration of 21 inches. The third shot, while placed equally well as the first two shots, was stopped cold by the entrance-side rib, giving only 4.875 inches of penetration.

The left photo above shows this third shot with the No Mercy stuck solidly in the entrance rib. The photo on the right shows the No Mercy's tip protrusion through the entrance-side rib. Examination of the broadhead revealed that the tip had bent at the rear edge of the triple thick tip overlay.

Occasional tip bends during heavy bone impact, though always of a modest degree, have been a persistent feature of Zwickey broadheads. They occur most commonly on quartering impacts or impacts located on a highly curved surface of a heavy bone. Obviously the angle of impact on this rib, as shown in the photos above, was sufficient oblique to cause the broadhead to bend, although part of the obvious deviation in direction of penetration through the bone is a result of the tip bend.

To take a closer look at the bend tendency of the No Mercy three freshly sharpened and never fired broadheads were mounted on newly tuned, tapered hickory shafts. The arrow setup was: Tapered hickory shaft; fletching, 5" four-fletch, parabolic cut; 10.0% FOC; Total mass, 776 grains.

Three shots were taken on the shoulder of a young adult male Asian buffalo from a quartering-from-the-front angle of 45 degrees, using the 64# ACS-CX bow. Testing distance was 10 yards. The first shot hit at the forward edge of the shoulder, missing the shoulder bones. It penetrated the entrance rib, angled back through the thorax and pierced the liver. Total penetration was 22.56 inches. The second shot impacted the scapula, resulting in a tip bend, and failure to stick into the bone. One edge on this broadhead was severely rolled, making the cutting ability of that edge near useless. Penetration was 4.875 inches. The third shot also impacted the scapula, resulting in a near-identical degree of tip bend, and failure to stick into the bone. Penetration was 4.25 inches.



Throughout the decades of testing the degree of tip bending exhibited by Zwickey broadheads has been exceedingly consistent. There has never been a case of total structural failure of a Zwickey broadhead, and no bends (caused by hard tissue impact) worse than those shown in the photos has ever been encountered. The photo on the left, showing a bent tip on an Eskimo, is from the original Natal Study; 26 years ago. Note the rounded tip profile that was being tested, all those years ago. The middle photo shows a more recent tip bend on an Eskimo; from the 2005 testing. The right photo shows the two No Mercy broadheads bent on the forward-quartering shots into the young buffalo's scapula.

Though no tissue-caused bends with the Zwickey have been encounter on any hits other than those obliquely impacting a heavy bone, the occurrence of tip bends on such hits, along with the modest hardness of the steel (which reduces retention of edge sharpness during tissue penetration), prevents the No Mercy from making my list off "best broadheads"; those broadheads one can rely on all types of hits. However, considering the extensive testing the various Zwickey broadheads have been subjected to during the Study's decades they have turned in far better overall performance than many other commonly used broadheads.

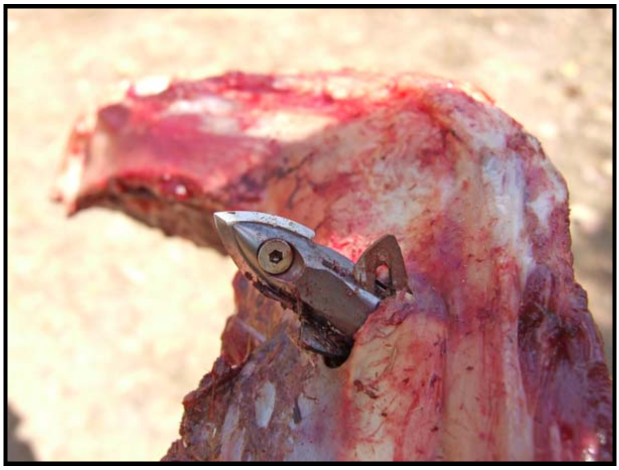
The Rage

The Rage is one of a long line of mechanical broadheads tested during the Study. To date, no mechanical broadhead has shown reliable, satisfactory performance on heavy bone hits, even when mounted on super heavy arrows and tested from compounds. The Rage was tested on an arrow setup with a weight below the heavy bone threshold, but still what many compounds shooters would consider to be a "heavy arrow". This setup was chosen because the performance against the ribs of the small buffalo chosen for testing would give some idea of how the Rage would perform on a heavy bone hit on lighter big game, when mounted on an arrow setup similar to what the average compound shooter might use on 'above deer size' game.

The arrow setup used was: carefully tuned Easton shaft with aluminum insert; 100 grain Rage broadhead; Fletching, 3" parabolic cut feathers; Total mass, 552 grains; FOC, 6%.

Three test shots were taken with a Martin Jaguar compound, set at 65#. All shots were from broadside, at 20 yards, on a young male buffalo of a size significantly smaller than a mature cow buffalo. All shots had well placed thorax impact.

The first shot breached the entrance side rib, giving 16.25 inches of penetration. The second shot failed to penetrate the entrance rib, with only the 'bacon skinner' tip sticking into the bone. Penetration was 3 inches. The third shot also failed to fully penetrate the rib, giving 4.5 inches of penetration; but there was a much more disturbing part of this third hit.



Above are photos of the two non-penetrating hits with the Rage. The photo on the right shows the tip of the broadhead from shot number three protruding from the inner side of the entrance rib. Note that this third shot struck the lower, thinner portion of the buffalo's rib, but impact is less perpendicular to the bone's surface than was shot number two. Also note that two of the blades of shot three are in a partially deployed position (only partially opened). When this broadhead was cut from the bone it was discovered that those two blades were bent to the degree that they could not be fully deployed, even with considerable force.

Had this third shot penetrated the bone the blades would have remained only partially deployed. The two severely bent blades would have created uneven drag, causing a deviation in arrow path and limiting penetration. The limited degree of blade deployment would also have rendered the wound channel cut-width less than optimally effective.

A Modified Grizzly with a Bleeder Blade

I wish to thank Mike Orton for supplying for testing three Modified Grizzly broadheads on which he had slotted the ferrule to accept a bleeder blade. I had long wished to test such a broadhead setup.

The broadheads came mounted on a short broadhead adaptor to permit room for the bleeder blade to pass through the forward portion of the ferrule. Average total weight of the finished broadheads was 184 grains.

Modified Grizzly with Bleeder Blades

After examining the broadhead's structure I did have some concerns with the setup. First, the bleeder blades used are double beveled, while the broadhead's main blade has a right single-bevel. Thus the broadhead's main blade is going to induce rotation as it passes through the tissues, while the bleeder blade is going to try and maintain a straight-line cut through the tissues. Would the flexible bleeder blades be bent by the difference in rotation between bleeder blade and main blade? How would penetration be affected by this difference in rotation?

The best performing bleeder blades ever tested in the Study are the original, thin, hard, brittle, blue carbon steel ones used in the original Bear Razorheads. When only in my early teens, I personally heard Fred Bear explain that the intended purpose of his bleeder blade was to open a wider wound channel through soft tissues TO REDUCE SHAFT DRAG AND INCREASE ARROW PENETRATION.

Fred intentionally chose to use thin, hard, brittle, high carbon 'razorblade' steel for his bleeder blades. The purpose, as he explained it, was so that the bleeder blade would always shatter instantly on impact with bone, rather than bend, thus "allowing the broadhead to penetrate just like any good single-blade". Incidentally, it was the use of this true razorblade steel (of the day) for the bleeder blades that gave rise to the name "Razorhead".

As an aside, it's unlikely that very many bowhunters younger than I remember the razorblade steel I'm referring to. It was the steel used in the early, double-edge replaceable razorblades. Compared to the near unbreakable, rust resistant stainless steel blades in use today, those early, carbon steel razorblades were very thin, very hard and easily broken, but incredibly sharp (until they rusted). It was once a common practice to snap triangular sections from those blue steel razorblades and then bond them to the rear section of broadheads. Plyobond; a contact cement commonly available at the time; was used to glue the bit of razorblade to the broadhead's blade, and the broadhead was then baked in the oven to 'cure' the glue. Properly applied those sections of razorblade would remain firmly attached, even when bone was penetrated, though their edges generally chipped when bone was hit.

For testing these 4-bladed, Modified Grizzly broadheads were mounted on Carbon Express Heritage 350 shafts, having a 100 grain brass insert. The shafts were bare shaft tuned using 190 grain field points that had been filed down to match the weight of the broadheads. Total weight of the finished arrow was 765 grains, and FOC was 24.8%. Impact force from the 64# ACS-CX bow used for testing was 0.50 Slug-Feet/Second.

Testing was conducted on a large male Asian buffalo. All shots were at a broadside shooting angle, from 20 yards. All shots had thorax impact.

Three test shots were taken. The first shot penetrated the entrance rib, giving 13.375 inches of penetration, and the bleeder blade appeared undamaged. The second shot penetrated the entrance rib, giving 13 inches of penetration, but on this shot each side of the bleeder blade was bent in a direction opposite the direction of the main blade's single-bevel induced rotation. The third shot penetrated the entrance rib, fully traversing the thorax to stop just touching the off side rib. Again both sides of the bleeder blade were bent in a direction opposite to direction of the bevel-induced broadhead rotation, though not as severely as on shot two. Penetration on this third shot was 18.75 inches.

I would have loved to do additional testing with these broadheads but the bleeder blades were bonded in place with what appeared to be JB Weld. Even had I been able to remove them I had no replacement bleeder blades, making further testing impossible.

The bent bleeder blades indicate that there is definitely a conflict of forces created between the straight cut of the double bevel bleeder blade and the spiraling cut created by the main blade's single-bevel. This results in a waste of arrow force. Whether or not these bleeder blades would be bent by the main blade's single-bevel induced rotation during an all soft tissue hit remains unknown, but the conflicting forces involved would undoubtedly cause some degree of penetration loss. Though the testing was very limited, and even though the bleeder blades bent, these broadheads turned in an impressive performance for a multiblade broadhead.

These limited tests definitely SUGGEST that a very good 4-blade broadhead; one capable of reliably handling even fairly heavy bone hits while still giving good penetration, even on fairly large game; might be developed by building upon these results. **On the other hand, these modified broadheads, as**

tested, did NOT reliably give sufficient penetration to be adequate for use on animals of buffalo class, or larger. Nothing less than an arrow setup capable of *consistently* giving thorax-traversing penetration, on shots from all reasonable shooting angles, can be considered adequate for hunting game of buffalo class.

For any interested in developing such a 4-blade broadhead, here's what I would suggest. First, I would stay with a high Mechanical Advantage broadhead, one having a profile similar to the Modified Grizzly used in these test, but I would prefer to start with a hefty, one-piece, screw mounted single-bevel broadhead having a solid ferrule. This would allow slotting of the ferrule to accept the bleeder blade without requiring that a short broadhead adaptor be used, weakening the broadhead's structural integrity. The second change I would suggest is to use a single-bevel on the bleeder blade; one that has a matching rotational direction to that created by the main blade's single-bevel. The third change would be the most difficult; make the bleeder blade from that same thin, hard, brittle, carbon razorblade steel used in the original Bear bleeder blades. While I was at it I would also give those brittle steel bleeder blades as long a taper as I could, for the highest possible MA.

Prototype: Nanook and Ashby Broadhead

Before getting into the test report on the prototypes of Alaska Bowhunting Supply's Nanook and Ashby broadhead one thing needs to be made perfectly clear; **I have no financial connection with Alaska Bowhunting Supply and receive no compensation from them.** A few years back the folks at Alaska Bowhunting Supply asked if I would assist them in developing the best broadhead design I could devise, and I agreed to do so. As development approached the final testing phase they asked if they could name that particular broadhead after me. I told them that I had two conditions for that: (1) the broadhead had to perform up to my expectation of what a "very best performing broadhead" should be, and (2) they had to place a disclaimer on their web site stating that I received no compensation from the project or product; neither for assisting in the development of the broadhead nor for the use of my name on the production broadhead. My only association with the Ashby broadhead was the provision of technical advice on design and construction features and the field testing of the broadheads during their development.

Nanook Prototype **Ashby Prototype**

This testing was on pre-production prototypes of Alaska Bowhunting Supply's Nanook and Ashby broadheads, and three individually produced and hardened samples of each head were supplied. The holes piercing the blades, as shown in the above photos, were for attachment of the steel blocks to a holding jig so that the one-off prototypes could be machined. The prototypes came as shown on the right, in each photo; without the Tanto tip. To the left in each photo is shown the Tanto tip added prior to testing.

Production Nanook **Production Ashby**

These photos show the production versions of the Nanook and Ashby Broadheads. Both are machined from a solid block of 440B stainless steel. The hardness specification is Rockwell 58. Blade thickness is 0.072". Each broadhead's edges are ground at 25 degrees, and the broadheads are available in either right or left single-bevel.

There are some differences between the prototypes and the production broadheads, besides the holes in the blades of the prototypes and the production Nanook's obvious vented-blade feature. The prototype Nanook tested weighed 335 grains, while the vented-blade production version weights 295 grains. Conversely, the prototype Ashby broadheads tested weight 295 grains, while the production version weighs 315 grains.

As this was the final field testing for the pre-production prototypes an unusually large number of test shots were taken, on multiple arrow setups. All test shots were from 20 yards, broadside, on very large and trophy class Asian buffalo bulls. Both the 82# longbow and the 64# ACS-CX were used during testing, with each arrow setup bare shaft tuned to the bow used for testing. Let's look first at the results with the Nanook.

The Nanook Prototype

The prototype Nanook was tested on three different arrow setups. The first setup was on a Grizzly Stick Safari shaft, with the factory brass insert and four-fletched with 2.5 inch A&A pattern fletching. Total arrow mass was 1055.5 grains, with an FOC of 24.7%. Impact momentum was 0.558 Slug-Feet/Second. This arrow was used from the 82# longbow. All shots had thorax impact, with all shots penetrating the entrance rib and fully traversing the thorax. A full 40% of the shots also penetrated the off-side rib, and one shot carried on to gave an exit wound. Average penetration was 19.15 inches. Minimum penetration was 16.625". Maximum measurable penetration (length of the wound channel through the tissues) was 24.88 inches. Median penetration was 19.0 inches.

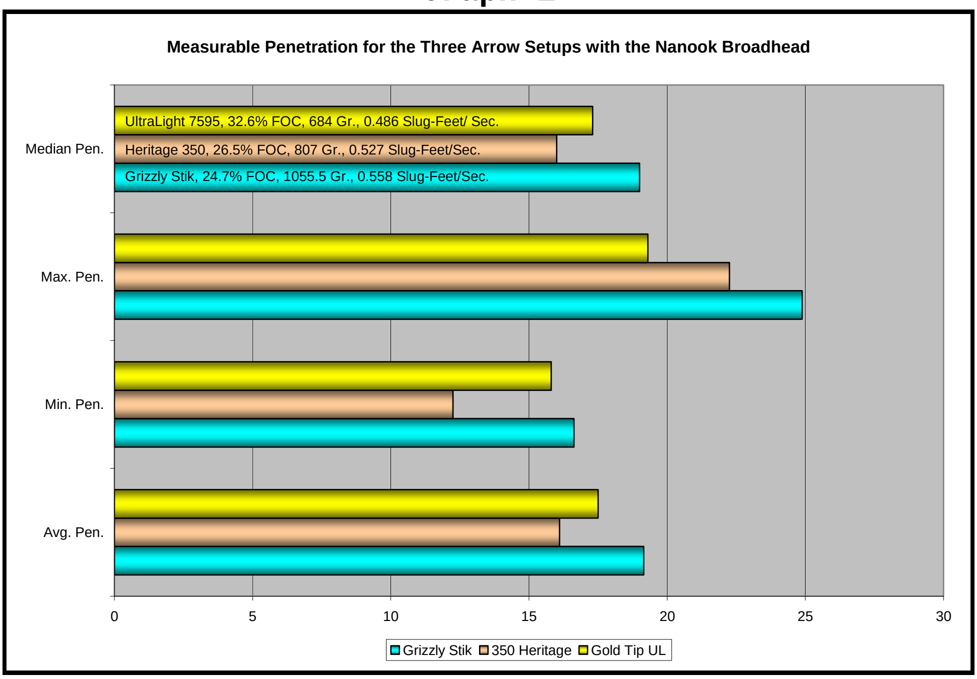
The next arrow setup tested was a Carbon Express Heritage 350 shaft having a 100 grain brass insert and four-fletched with 2.5 inch A&A pattern fletching. The total arrow mass was 807 grains, with a FOC of 26.5%. Impact momentum was 0.527 Slug-Feet/Second. Testing was conducted with the 64# ACS-CX and under the same testing conditions as the previous setup. All shots with this arrow setup breached the entrance rib and fully traversed the thorax, with each sticking solidly into the off-side rib. None, however, breached the off-side rib. Average Penetration was 16.1 inches. Minimum penetration was 12.25 inches, on a low shot that breached the entrance rib, passed through the lower heart and stopped in the off-side rib. Maximum penetration was 22.25 inches. Median penetration was 16.0 inches.

The third setup tested was on a Gold Tip UltraLight 7595 shaft having a 100 grain brass insert and four-fletched with 2.5 inch A&A pattern fletching. Total arrow mass was 684 grains, with a FOC of 32.6%. Impact momentum was 0.486 Slug-Feet/Second. Testing was done with the 64# ACS-CX longbow, under the same conditions as the two prior setups. Again all shots breached the entrance rib, fully traversed the thorax and stuck solidly into the off-side rib, with none breaching the off-side rib. Average penetration was 17.5 inches. Minimum penetration was 15.8 inches. Maximum penetration was 19.3 inches. Median penetration was 17.3 inches.

During the testing none of the prototype Nanook broadheads were damaged, and all exhibited an amazing level of retained sharpness after penetrating the buffalo. All shots, with all the arrow setups, at a minimum fully traversed the thorax and encountered the off-side penetration barrier.

Graph 1 depicts the median, maximum, minimum and average penetration for the three arrow setups with the Nanook broadhead. Setups with the Grizzly Stik and Heritage shafts carry EFOC. The UltraLight shaft setup has Ultra-EFOC. Remember that "penetration" reflects the length of the wound channel through the tissues and that 40% of the shots utilizing the Grizzly Stik also penetrated the off-side rib, with one shot carried on to gave an exit wound. This non-measurable penetration is not reflected by the graph.

Graph 1



The Ashby Prototype

The Ashby prototype was tested on only two arrow setups. The first setup tested was on a Carbon Express Heritage 350 shaft having a 100 grain brass insert and fletched with 2.5 inch A&A pattern fletching. Total arrow mass was 737 grains, with a FOC of 25.8%. Impact momentum was 0.480 Slug-Feet/Second. Testing was conducted on very large adult and trophy class Asian buffalo bulls, using the 82# straight end longbow.

The first test conducted with this arrow setup was to determine if this combination was capable of penetrating sufficiently on a spine hit to sever the spinal chord. Thanks to my less than sterling 20-yard shooting, it took several attempts to connect with a vertebra, but the broadhead that finally connected was buried totally in the bone, severing the spinal cord.

During the numerous attempts to hit the spinal cord a problem was noted with one of the broadheads. On its first shot, which was high, hitting the dorsal process just above the spine, several small chips were broken from the blade's edge. These were laboriously honed completely away before that broadhead was shot again, and the broadhead was marked so that it could be identified. On its very next shot, which impacted the upper portion of a rib, immediately below the spine, and penetrated through both the on-side and off-side ribs, chips again were broken from the blade. At that point, this sample was removed from the testing. During the balance of the testing no other blade chips were encountered on the remaining prototype broadheads; neither the Nanook nor Ashby.

With all stainless steels I've tried there is a very fine line between a hardness that will not yield rolled edges and the hardness where the steel chips on very hard impact. While it is suspected that this chipped broadhead had been hardened above the called for specification, rendering the steel too brittle, hardness below R57-R58 on the stainless steel used allows the edge to roll when the low angle, 25 degree single-bevel is used. Hopefully the tempering of the production broadheads will make such an overly hard broadhead a rare occurrence.

There are distinct advantages to the 25 degree bevel angle and, given the choice between a broadhead that bends (or rolls an edge) and one which chips or breaks on hard impact, it is always preferable for the broadhead to chip or break. It has a far less detrimental effect on terminal performance.

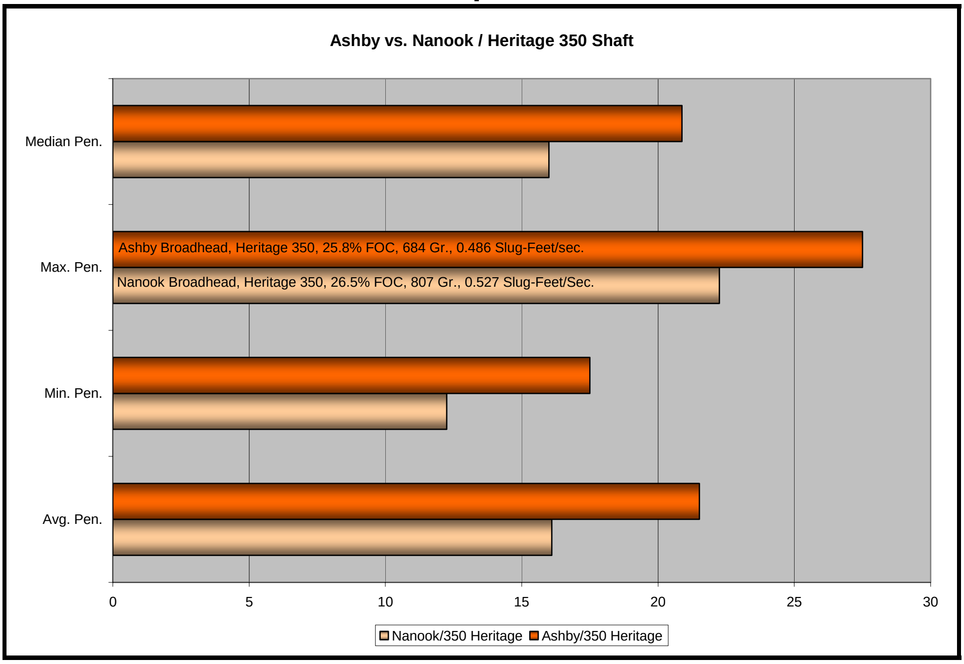
Second set of edge chips on the one, likely over-hardened, prototype Ashby broadhead.

Next this same arrow setup was tested in the standard format; from 20 yards, with broadside impact into the thorax. All shots breached the entrance ribs and fully traversed the thorax. The broadhead was firmly stuck into the off-side rib on 71% of the shots, with 29% of the shots breaching the off-side rib. **Most impressively, every shot that managed to breach the off-side rib carried on to produce an exit wound, with some coming within mere inches of achieving a total arrow pass-through.**

As with the Nanook, each of these shots fully traversed the thorax and average penetration becomes a moot point but, for the record, the average penetration for all thorax shots taken with this arrow setup was 21.52 inches. It must be remembered that "penetration" is measured by the length of the wound channels through the tissues, and 29% of these shots produced exit wounds, with some achieving near pass-through hits. The minimum penetration was 17.5 inches. Maximum (measurable) penetration was 27.5 inches. Median penetration was 20.88 inches.

It is worth noting the terminal performance difference between this arrow setup and the second arrow setup tested with the Nanook. Both setups utilize the same shaft; the Carbon Express Heritage 350. The setup with the Ashby broadhead carries 8.7% less mass, 2.6% less FOC and 9% less impact force yet it yielded greater average penetration, with 29% of the shots not only breaching the off-side ribs but also carrying on to produce exit wounds; as opposed to no shot with the Nanook managing to breach the off-side ribs. This is yet another, extremely graphic demonstration of the effect higher broadhead Mechanical Advantage has on penetration. Graph 2 shows these results.

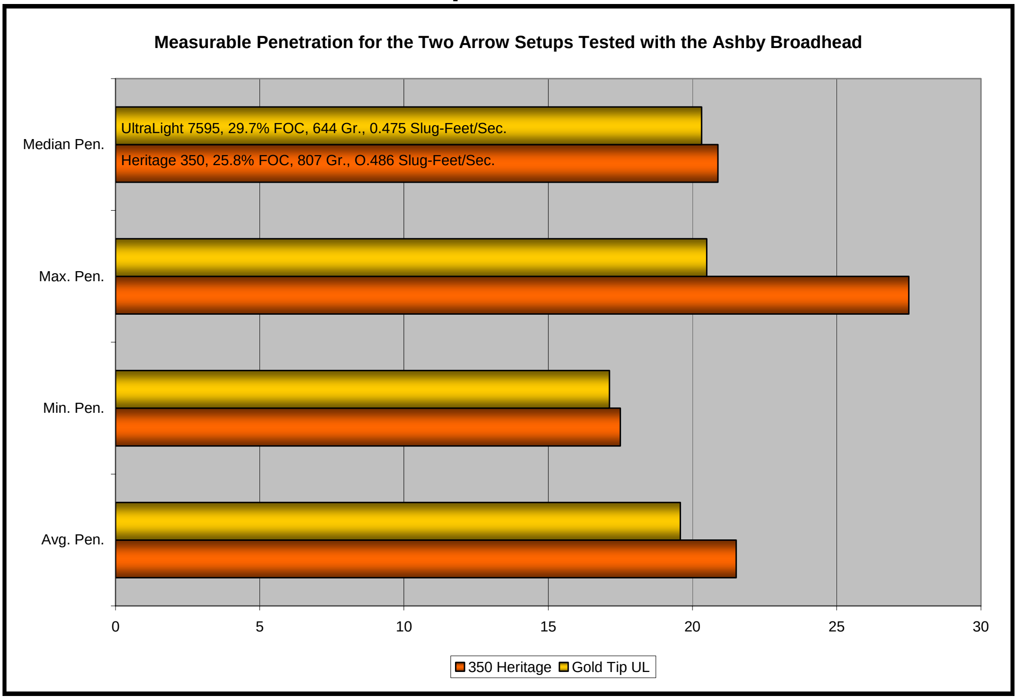
Graph 2



The second arrow setup tested was on a Gold Tip UltraLight 7595 shaft having a 100 grain brass insert and four-fletched with 2.5 inch A&A pattern fletching. Total arrow mass was 644 grains, with a FOC of 29.7%. Impact momentum was 0.475 Slug-Feet/Second. This setup was tested from the 64# ACS-CX longbow. The shots were at 20 yards, from broadside on a trophy class bull. One wayward shot hit high, slicing into the lower portion of a vertebra, penetrating the on-side rib and sticking into the off side rib. All remaining hits were well placed in the thorax region, with all breaching the entrance rib and fully traversed the thorax, sticking solidly into the off-side rib. None of the shots, however, breached to off-side rib. Average penetration for all thorax impact shots with this arrow setup was 19.58 inches. Minimum penetration was 17.13 inches. Maximum penetration was 20.5 inches. Median penetration was 20.32 inches.

The following graph depicts the median, maximum, minimum and average penetration for the two arrow setups with the Ashby broadhead. Remember that "penetration" reflects the length of the wound channel through the tissues and that 29% of the shots utilizing the heavier Heritage shaft also penetrated the off-side rib, with every shot penetrating the off-side rib also carrying on to give an exit wound. This non-measurable penetration is not reflected by the graph.

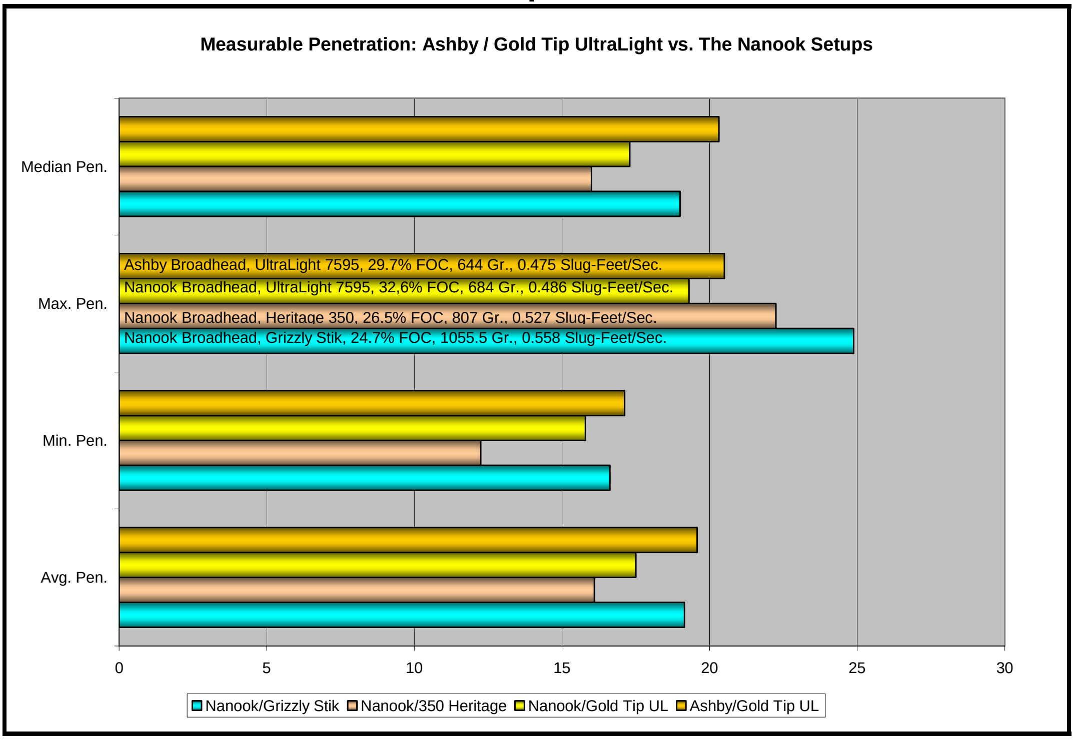
Graph 3



Once again, an interesting comparison can be made between the second arrow setup with the Ashby broadhead, the one using the UltraLight shaft, and all three arrow setups having the Nanook broadhead. This right-at threshold mass arrow with the Ashby broadhead carries 39% less mass than the first setup tested with the Nanook, 20.2% less mass than the second setup with the Nanook and 5.9% less mass than the third Nanook setup. While it has a 20.2% FOC increase over the first setup with the Nanook (29.7% vs. 24.7%, which represents an *increase in the percentage of FOC* of 20.2%), and 10.6% more FOC than the second Nanook setup, it has 8.9% less FOC than the third Nanook setup. It also has 14.9% less impact force than the first Nanook setup, 9.9% less than the second setup and 2.2% less than the third. Despite its lower mass and impact force its average, minimum and median penetrations exceed those for any of the Nanook arrow setups. This, too, is a simply a function of the Ashby broadhead's higher MA, as shown in Graph 4.

It is only in the maximum measurable penetration that the substantially heavier Grizzly Stik and Heritage shafted Nanook exceeds the right-at-threshold-mass UltraLight with the Ashby broadhead. Once the on-side rib was breached the higher MA of the Ashby broadhead allowed the lighter arrow to do more work with the force it retained, but the retained force was insufficient to breach the off-side ribs, once it was reached. Taken collectively, Graphs 1 through 4 present an interesting study of the interrelationship of the penetration effects of arrow mass, broadhead MA, arrow FOC and retained arrow force.

Graph 4



As with the Nanook, the retained sharpness of the Ashby broadheads, after passing through the buffalo, was outstanding. The only other broadhead tested that has shown comparable retained edge sharpness after penetrating the Asian buffalo tissues is the SilverFlame. The biggest advantages the Nanook and Ashby broadheads have over the SilverFlame are the stronger one piece construction, the vastly superior ferrule profile, the bone-splitting advantage of the single-bevel edge design and, in the case of the Ashby, the vastly superior Mechanical Advantage of the broadhead.

A Brief Broadhead Mechanical Advantage and Edge Bevel Summary

It's worthy of reiteration that the Study data shows that **EVERY** *structurally intact*, 'above the heavy bone threshold' arrow having a broadhead with a MA above 2.6 has managed to penetrated the entrance side ribs in the buffalo testing; regardless of whether the broadhead was of single-bevel or double bevel design. This applies for all draw weight bows tested, from 40# to 82#. **The big performance differences between single-bevel and double-bevel broadheads comes in the bone**

breaching rate when arrow mass is *below* threshold and in the average amount of penetration achieved AFTER THE BONE WAS PENETRATED, regardless of arrow mass.

On shots impacting heavy bone: (1) When compared to ANY comparable double-bevel broadhead mounted on a comparable arrow setup EVERY structurally intact, 2.6 MA (and above) single-bevel broadhead tested (100%) has shown a greater rate of bone penetration *when arrow mass was below the heavy bone threshold.* (2) When compared to ANY comparable double-bevel broadhead mounted on a comparable arrow setup and, regardless of whether the arrow's mass was above or below the heavy bone threshold, EVERY structurally intact 2.6 MA (and above) single-bevel broadhead tested (100%) has shown greater average post-breaching penetration.

Having a 100% occurrence of any outcome across such a large sample size is a very, very rare occurrence in outcome driven testing, but it highlights the significance and level of influence the single-bevel broadhead edge has upon the bone splitting ability if a broadhead, as exhibited by both the frequency of bone breaching by below-threshold mass arrows and the difference in post-breaching penetration with arrow of all mass weights. **In must be noted that this penetration difference can not be exhibited in just any test medium. Different materials have different fracturing characteristics. These differences were measured and documented in fresh, in situ bones. Results in test mediums having different fracture characteristics would likely differ. Even dried and slightly dried bone - which I have tested extensively - does not fracture the same as fresh, in situ bone.**

Both broadhead MA and broadhead bevel type/design are major factors in breaching heavy bone; using less of the arrow's force during bone breaching and retaining more of the arrow's force for post-breaching penetration of the underlying tissues. A clear example is shown in the 2007 Update, Part 4, in the section titled *Another Look at Single-Bevel vs. Double-Bevel Broadheads*. There, the penetration outcomes of arrow setups that were identical, excepting only the broadhead's type of edge bevel, are compared.

In the Part 8 Update we'll look at some of the practical aspects of applying the Study's information to your own arrow setup.