Arrow Lethality Study Update – 2005
Part I

By
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During the last year the information in the database has grown to over 450 primary shot records, plus substantial data from several "focal studies". Each individual shot record contains over a hundred 'data bits', not including the 'associated data' in the related broadhead specifications and chronograph databases. There is a great deal of information to sift through. Presentation of the current information represents only a snapshot of the highlights, yet its presentation will require division into several articles.

Initial testing has concentrated on the Asian Buffalo. As this data comprises the bulk of study data, updates are confined to the Asian Buffalo data.

Throughout the updates, the reader should bear in mind some of the study definitions, parameters and protocols. "Penetration" as used in the study refers to the depth of the wound channel through the tissue. In recording the penetration of a shot giving an exit wound, even a pass-through shot, the "penetration" is the length of the wound channel through tissue. The presence of any exit wound, its location, description and degree of arrow protrusion are recorded elsewhere in that shot's individual record.

"Penetrated" means complete passage of the broadhead through a structure. For a rib or scapula to be "penetrated" the entire broadhead must pass completely through the bone. The tip of a broadhead protruding out the back side of a bone does not constitute penetration of the bone. The broadhead's/arrow's penetration was stopped by the bone; it did not penetrate *through* the bone.

The kinetic energy and momentum measurements referred to throughout the updates are the levels at impact, not those as the arrow leaves the bow.

As data graphics are presented; chart (table) or graph; I will try to annotate important data facets the reader should consider when evaluating performance. The study is far from complete. Data is 'interim', and outcomes may change in the final analysis.

Information from recent focal studies is presented first in the updates, beginning with tip design testing.

Broadhead Tip Design

The first 'focal study' test conducted during the 2005 buffalo studies was to evaluate the effect broadhead tip design has on broadhead durability and hard tissue penetration.

The broadheads used were Tusker Concords. The Concord is a 155 gr. broadhead with a long and narrow profile, having a 1.115″ cut width and a cut edge length of 2.651″. In earlier buffalo test it had shown a tendency to bend frequently, especially with adverse angle bone impact.

Forty-two of these broadheads were used for testing; six each of seven different tip profiles. Six of the heads retained the factory needle tip. Six were modified to each of the following tip profiles: flat (squared off at the tip); chisel (squared off and sharpened to a cut-on-impact (COI) edge); COI arch; COI round tip; COI Tanto tip and COI concave tip.

Broadhead edges were sharpened with a double bevel of 25 degrees, for a 50^0 total sharpening angle, with edges honed and stropped to a true shaving edge. All were mounted on tapered hickory shafts. Shaft/broadhead combinations were matched to give no more than plus or minus 7.5 grains maximum variation in total mass. Both the average and median arrow mass was 771 grains. To facilitate placing all impacts on the scapular flats, shooting was done at a range of 10 yards.

All shots were with a longbow of 70# draw weight. Average impact momentum (Mo) for the test arrows was 0.442 Slug-Ft/Second. Average impact kinetic energy (KE) was 28.48 ft.-lbs. The low impact force was chosen so that most of the broadheads would be unlikely to penetrate the scapula flat.

Testing was conducted on two freshly culled buffalo; a young adult male and an adult female. Three shots were fired with each tip design into the scapular flats of each buffalo. All shots into the young male were fired from a broadside position, with arrows striking perpendicular to the bone's surface. All shots into the adult female buffalo were fired quartering from the front, giving a sharply oblique 40^0 angle of impact on the bone.

Chart 1 shows the test results. Test numbers are fairly low, but indicate a clearly defined tendency. Even at low impact force, COI tips having round or Tanto profiles show a marked increase in frequency of bone penetration and a low frequency of damage. No broadhead with a flat, chisel or concave configuration penetrated the scapular flat. Needle tipped broadheads had a low frequency of penetrating the scapula, and a 100% bend rate.

The arch profile faired only slightly better than the flat, chisel and concave. Durability of the Tanto profile was of no surprise. In all prior testing no tip of Tanto profile has suffered damage.

Numerous queries have been received asking, "What is a Tanto tip, and what does it look like?" The term "Tanto tip" is one I coined over a quarter century ago, and chosen merely because the profile reminded me of two Tanto knives placed back to back.

Accompanying photos should clarify what a 'Tanto tip' looks like. "Tanto tip" is a profile, and can be applied in any width; ergo, one can have a "narrow Tanto tip" or "wide Tanto tip"; a "COI Tanto tip", such as I change the Grizzly's factory tip to, or a non-COI Tanto tip, such as the Grizzly's factory tip.

After conducting these tip design test, a number of broadheads previously demonstrating a tendency for tips to break or bend were modified to a COI Tanto profile. In tests subsequent to these modifications no incidences of tip damage were encountered.

It should be noted that broadheads selected for tip modification were those that had shown good blade strength, edge retention, and steel quality, but with a *frequent tendency* to bend/break in the area of the tip. This encompassed the Abowyer Custom; Eclipse; STOS; Wolverine; Magnus II; and Zwickey. The BlackStump was added to this list mid-way through this year's testing.

Edge Bevels

After the examination of hundreds of shots penetrating through bone, by a multitude of different broadheads, a consistent difference was noted between single and double bevel broadheads in the frequency of bone *splits*.

In the bone-split photos accompanying, note the long splits in the buffalo rib bones caused by the single bevel Grizzly. These are a normal occurrence, but frequently are not easily visible until the bone is thoroughly cleaned and/or dried. Commonly these splits extend 4" to 6" from the point of blade entry into the bone. Clearly visible in the photos is the "S" shaped hole created as the single bevel broadhead rotates while passing through the bone, as opposed to a straight cut created by the double bevel broadhead. The double cut broadhead hole in the photo is from a Deadhead.

It is theorized that the torque force applied by the broadhead's rotation causes the bone to be 'popped apart'. This splitting of bone shows a higher frequency on ribs and long bones (humerus, femur) than on flat bones (scapula), but is common in both. It is plausible speculation that a single bevel broadhead may tap into the arrow's rotational energy during this penetration, achieving useful work from arrow energy generally not gainfully employed in penetration.

The splitting of bone, as opposed to cutting a blade-size hole through it, is a desirable feature in broadhead design. The measurable penetration difference indicates that it permits easier passage through the bone, reducing arrow drag and increasing overall penetration.

A series of focal studies was conducted to test the effect of the type of edge bevel on penetration when bone is encountered. Thanks to Ben Pearson Jr. I was able to secure

some Deadhead blanks that had never had an edge bevel applied. On these I applied a 25^0 right hand single bevel (25^0 total edge angle). These were used as a comparison to Deadheads having a 25^0 double bevel edge finish (50^0 total edge angle).

Alan Woodward, maker of the Outback Broadheads supplied several samples of his broadheads; some with a right hand single bevel; some a left hand single bevel; and some with double bevel. Several samples of each edge bevel type were supplied in both long-narrow and short-wide broadhead configurations. The single bevels were also set at 25^0 (for a total edge angle of 50^0).

Chart 2 shows the comparative results from testing the single and double bevel Deadheads. Chart 3 reflects results with the experimental Outback broadheads.

All shots were taken from a broadside shooting angle at 20 yards. Each shot series were fired in matched sets so that equality between test subjects and edge types tested was maintained. The Deadheads were tested on tapered hickory shafts from a 70# longbow. The Outback's testing was with aluminum shafting and a 65# Compound.

On shots impacting a rib the single bevel Deadheads show a 31% increase in average penetration over the double bevel Deadheads. When the scapula is hit the single bevels show a 40% increase in penetration.

The Outback broadheads were used only on rib shots. The narrow single bevels show an increase in penetration of 58% over those with double bevels. Wide cut single bevels show a 49% increase in penetration.

Two shots each were taken with a narrow and a wide cut left hand single bevel mounted on a right fletched shaft. This created a situation where the direction of rotation caused by the broadhead's bevel is opposite the direction of arrow rotation in flight. These show a decrease in penetration from the corresponding right hand beveled samples of 42% and 67%, respectively. With single bevel heads it is important that the direction of arrow rotation in flight match the direction of rotation caused by the blade's bevel.

While this is fairly limited sampling, comprising only 45 shots, the findings were consistent, with three broadheads of vastly differing profiles. They represent a coherent tendency; with both the average penetration and the median penetration showing a clear advantage for single bevel broadheads in penetrating through bone. This is *strongly suggestive* that single bevel broadheads offer a marked advantage in penetration through bone.

Chart 1

Broadhead Tip Design Test

N_{Total}=42

Test Broadheads: Modified Concord.

For all shots: Arrow Mass = 771 Gr. ± 7.5 gr.; Impact Momentum = 0.442; Impact KE = 28.48						
Six shots with each tip design: 3 shots, each tip design, at approx. 40^0 quartering from the front on an adult female Asian Buffalo; 3 shots, each tip design, from broadside on a young adult male Asian Buffalo.						
All Impacts: Scapular Flat Range: 10 yards.						
			Number			
		Number	**Pen.**	**Average**	**Range Of**	**Median**
	Tip	**Broadheads**	**Scapular**	**Penetration**	**Penetration**	**Penetration**
N=	**Design**	**Damaged**	**Flat**	**(Inches)**	**(Inches)**	**(Inches)**
6	Tanto	1	5	9.73	6.4 - 12.1	9.07
6	Round	2	4	7.63	5.0 - 10.1	7.75
6	Chisel	2	0	6.00	5.5 - 6.6	5.94
6	Arch	3	1	5.63	5.0 - 7.1	6.06
6	Concave	0	0	4.63	4.5 - 5.0	4.50
6	Needle	6	1	5.33	4.9 - 6.1	5.00
6	Flat	2	0	5.42	4.8 - 6.4	5.06

Chart 2

Deadhead Bevel Test

N_{Total} = 20

			Average				
			Impact	**Average**	**Average**	**Penetration**	**Median**
		Avg.	**Kinetic**	**Impact**	**Penetration**	**Range**	**Penetration**
N=	**Deadheads**	**Mass**	**Energy**	**Momentum**	**(Inches)**	**(Inches)**	**(Inches)**
5	Double Bevel: Scapula Impact	770	31.62	0.46	7.75	5.9 - 7.6	7.25
5	Single Bevel: Scapula Impact	770	31.62	0.46	9.85	5.4 - 12.1	10.25
5	Double Bevel: Rib Impact	770	31.62	0.46	12.03	2.8 - 20.0	13.875
5	Single Bevel: Rib Impact	770	31.62	0.46	18.03	14.9 - 22.9	18.125

Chart 3

Experimental Outback Test

N_{Total} = 25

			Average				
			Impact	Average	Average	Penetration	Median
	Exp. Outback	Avg.	Kinetic	Impact	Penetration	Range	Penetration
N=	(Rib Impact)	Mass	Energy	Momentum	(Inches)	(Inches)	(Inches)
8	*Narrow Cut Double Bevel	684	44.58	0.52	12.75	9.8 - 11.6	11.63
5	Narrow Cut Single Bevel	662	43.99	0.51	17.63	14.5 - 19.25	18.125
4	Wide Cut Double Bevel	660	43.85	0.51	10.59	7.0 - 15.3	10.06
4	Wide Cut Single Bevel	660	43.85	0.51	14.28	12.0 - 15.3	14.94
2	Left Narrow Cut Single Bevel Right Fletch	662	43.99	0.51	10.75	8.0 - 13.5	10.5
2	Left Wide Cut Single Bevel Right Fletch	660	43.85	0.51	4.94	4.9 – 5	4.96

- **Includes 3 shots with a prototype thicker, heavier, blade of same profile.**

Tip designs tested included, from Left: Original Needle Tip; COI Arch; COI Round; COI Tanto; Flat; COI Chisel (flat); and COI Concave

Tanto tip on an Eclipse

Tanto tip on a STOS

ABowyer Custom with original tip (Lower) and Tanto tip (Upper).

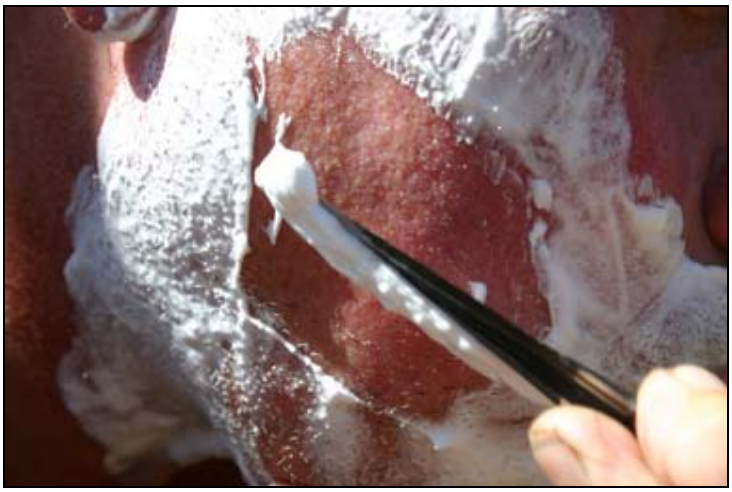
Exit side single-bevel bone splits (Left) and double bevel 'hole' (Right).

Entrance side; double bevel (Left) and single bevel (Right). Five-inch split (R) was caused by 11/16" wide Grizzly Extreme.

Single bevel induced rotation is clearly visible.

Single beveled Deadhead.

Narrow and wide cut Outback broadheads with single and double bevels.



How sharp should a broadhead be to hunt with? As this un-retouched photo of a 190 gr. Grizzly shows, it should be 'true shaving sharp'! CAUTION: Do not attempt this unless you are experienced at shaving with a straight-edge razor.