African Bowhunting

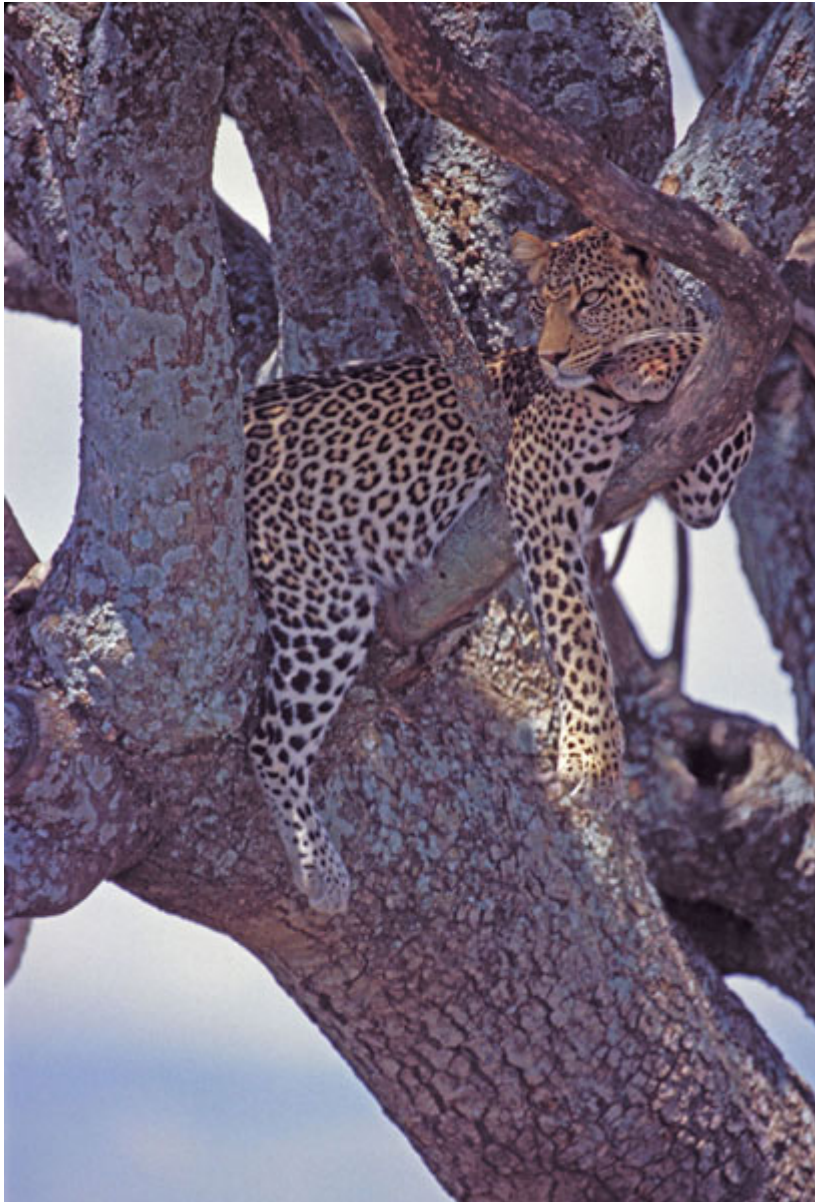## the theory and the practice

Compiled by Harry Marx

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This book is also used by the South African Bowhunter's Association for its Bowhunter Proficiency Certificate (BProC)

In this introduction to bowhunting the focus is on
the theory, practice, reasons and larger picture for
the curriculum. These proposed practices for
bowhunting are implemented in SABA's Bowhunter's
Proficiency Certification (BProC). Later on we talk
about the animals themselves, hunting tips, etc. The
idea of self regulation can only work if you have the
tools with which to make informed decisions. The
attitude we take in this book is therefore to provide
you with these mind tools, and not to define rules.

Contents:

1   Foreword

This book, or project, is very much a product "in the making". It is also a product that evolves with new technology and insight. And then it is not a product of one person, but rather a collaborative work by many bowhunters and technical minded ones. It contains a lot of theory, to underwrite two concept we followed: one - we question every opinion and try to find scientific evidence for or against it, and two - we test the outcome of the theory against what is seen in practice. It is not needed to know or understand this theory to hunt successful, but if you want to tell someone how they should hunt, you better have some scientific backing. Some of the ideas is still very speculative, and lacks experimental backing, but the major thrust is to build theory that explains, and not only describes, what we see. And then it contains lots and lots of practical information. The practical side of it also growing, evolving, and adapting...

2   Introduction

A note on conventions: All the text that is marked like this, is considered as crucial to bowhunting.

2.1   Why Bowhunt?

Bowhunting can be easy, or very difficult, as you choose. Sitting in a hide, you only need to have lots of patience. Hunting by "walking and stalking", with a bow however, can be very challenging. You need to get very close to the animal, and then draw the bow, and shoot, without being seen.

But in general, hunting with a bow is a much more intimate process than doing it with a rifle. You need almost to smell the animal before you can shoot. Frequently the hunter sees the bleeding animal, and sometimes sees the animal goes down. However the bowhunter strives for a quick kill, which is the very central objective of this book.

Further Reading: Engee Potgieter, **AB&A**, Feb 2008, p19, *"Why Bowhunt?"*
Ricardo Rademeyer, **AB&A**, Feb 2009, p27, *"Respect your quarry"*
Seppie Celliers, **AB&A**, Apr 2009, p53, *"Jy moet eers kruip voor jy kan loop"*
Herman Brand, **AB&A**, Apr 2008, p54, *"Waar is die pret?"*

2.2   Is "minimum requirements" for hunting sensible?

Before we can discuss the theory of penetration, we need to make a judgment call on a more fundamental issue - when do we consider penetration as "enough"? In other words, when do we consider an arrow that hit its target, as lethal? This sounds rather strange, since we all know exactly when an animal is dead or not. The question we are posing is of a slightly different nature. Yes, we know whether a particular animal is dead, but we need to determine when it would have died, before we make the shot! Hindsight is not allowed.

In general, when measuring any attribute of a system, you will probably get a slightly different reading each time you do the measurement. And getting a more accurate chrony will help only slightly, since it only measures the differences with more accuracy. Such measurements usually group around an average, which is usually very close to the "real" value. What is very important to notice about this situation, is that no matter how many times you measure an attribute there is always a chance that the next measurement will be smaller than the smallest you have made so far. And the more measurements you make, the bigger the chance you will get an even smaller one...

In contrast to this, the more measurements you make the better these values group around the real value. In more scientific terms, the error you make on using the average of the measurements to predict the real value, decreases with an increase in the number of measurements.

In bowhunting terms, this simply means that no matter what minimum value you quote, based on the success of a hunt, someone will kill the same species with a lesser arrow.

We can compare this dilemma with a similar one faced in the pharmaceutical industry when they try to define exactly how lethal a poison is. One solution they found was the so called LD50 value. This is a dose at which half the animals died, and half survived, when tested. But we are interested in what dosage will in "all" cases results in death. Clearly, there are people that survive even severe overdoses. Likewise in hunting, we would like to apply an arrow that in "most" cases, results in a quick kill.

The question we therefore ask is what percentage of the experimental animals must have died before we as hunters would call the arrow "enough"? (Enough then being the "minimum requirement".) Let us just for the sake of argument consider a LD80 as "enough".

The next step would then be to classify all hunts in two categories, kill or wound. We can then simply draw a graph of all the arrows against these two categories, and thereby see where 80% of the hunts were successful. But here we run into a slight problem.

LD50 values are no longer generated for new chemicals. Anyone can guess why? For one it is extremely expensive, and for two, it is not a very humane procedure. Likewise, I doubt if even a few of us has a budget to do this on a hunting scale, let alone the time, and the animals.

Another approach would then simply be to use all the data as reported by all the hunters. Problem with this is that one, the number of wounds are always under reported, and two by the nature of hunting, hunters try and avoid the wounding half. So we are left with data that portrays only one side of the coin, lethal hits.

This brings me back to the general observation made previously, we have only lethal hits, and forever somebody will have a successful hunt with a lesser arrow/bullet. But we know, there is some minimum value where the arrow will simply bounce of the animal, and determining it is not really difficult. We would need to start with a ten pound bow, and slowly increases the poundage, until the animal dies from the wound in an acceptable time.

Research done by Friis-Hansen (1990) indicated that a 15mm wound diameter penetrating to half the thorax's depth is lethal generally within 10 seconds. A 7.5mm wound needs to traverse the whole thorax before it is as effective. The problem is therefore not to determine the minimum required damage, but what's the minimum required arrow that will cause it. The cutting diameter suggested is much less than what we would consider a standard hunting tip - 1" (25mm). Which is good - we are on the safe side. The question however is how deep can our equipment push it? For the average senior male compound hunter, this question is of less importance, but to women, younger, and traditional hunters, this question is crucial. Also, if accuracy is affected by too much draw weight, a good approach to regain it is to reduce the poundage - but how far can we go? More on this later, see Required Penetration Depth.

There is a more fundamental issue with minimums - everybody (as per human nature) would adapt to simply satisfy this minimum value. You can imagine the increase in wounds, even with good shot placement (bear in mind that the arrow/bullet, although aimed at the lethal area, and even hitting it, is not guaranteed to penetrate "as advertised".)

We would like to suggest an alternative with this book, to use the average of the ballistic attributes of all lethal shots, as an optimum value. The closer your setup is to this optimum, the better your chance of using equipment that is "enough". This may indeed lead to a situation where some people, by choice or ignorance, accept these values as absolute minimums. We therefore try to indicate with each optimum value, the range of acceptable values, by providing some measure of the minimums as well. (Again, by definition, minimums are very unreliable and unpredictable.)

We then suggest that as a hunt is planned with each hunter's accuracy in mind, likewise it comes natural to consider the degree to which the hunter's equipment satisfies this optimum.

3   In Theory

3.1   Penetration Ability

The biggest factor affecting a hunt is shot placement. The meanest arrow that misses a vital organ is going to cause great suffering. Therefore the first general guideline is always to choose the highest poundage that can still be shot accurately. Accuracy should never be compromised in favor of penetration ability (PA) (or generally referred to as KE or momentum). The target species should then be limited as suggested by your set-up.

As a general rule of thumb, it is proposed to shoot with the heaviest arrow that still attains about 240-250fps. A quicker arrow will not be a safeguard from string jumping (where the animal being shot at tries to escape when hearing the bow or arrow's sound), instead the best protection is to limit the distance of the shot (or to make the bow as quiet as possible). The effect of increasing the speed or decreasing the distance will theoretically have the same influence on the animal's time to react. However, to gain speed a compromise with lower arrow weight or higher draw weight has to be made, which in turn effects penetration ability (PA) or accuracy.

Further Reading: Koert Pretorius, **AB**, Nov/Dec 2000, p19, *"Jumping the string"*

There are people that propose that the biggest factor is actually not shot placement, but penetration ability. They are not wrong. (We will discuss it as the 2nd biggest factor.) The reason for this divide is simple. Hunters with above adequate equipment, have less problems with penetration, and more with shot placement. Hunters with marginal equipment have more trouble with penetration than shot placement. We simply believe the majority of people do have adequate equipment.

In defining the minimum recommendations, no absolutes can be stated, since there is simply no minimum force which will result in death. For ex., a knife can be used to kill extremely successful. When we are talking about the minimum recommendations for hunting, of course a knife is generally not acceptable. So an assegai can also be subject to analysis. Spears carry between 100 and 160 ft.lbs of energy and about 4 slug-feet/second of momentum, and they weight about 2 to 5 pounds. This is far beyond all generally suggested minimum recommendations even for hunting elephants and hippo. Clearly, the particular tool has a major influence on our opinion as to its suitability. In fact this hints to the unsuitability of energy or momentum, and suggests rather a new one of *optimum penetration ability* (PA), that will become the focus of this book. This optimum values should suggest values that reduce the risk, and are close to generally used values.

At the same time care should be taken that these optimum values are not interpreted as "minimum" by the casual reader. If we for example look at arrow weights as recommended for buffalo, a value of 900gr may seem excessive. Again, this should be seen as an optimum value. A sensible absolute minimum would probably in the region of 720gr, or about 80% of the suggested value. Therefore, although 900gr is suggested, the software accompanying this manual uses 80% of this recommendation as minimum value for all values.

Of course absolute minimums do exist, and can easily be demonstrated with the inability of a blunt stick thrown at an animal. We will try and answer this as well.

🔴The second biggest factor affecting a hunt is this *penetration ability*(PA).

Although kinetic energy and momentum are traditionally used as indicators in the hunting community, it has severe shortcomings when applied to <u>low energy weapons</u> as discussed above, and is being replaced by something called *momentum density*, but more about his later. High energy projectiles kill not only due to the passage of the projectile, but also due to the cellular damage caused by high energy shock waves generated by these projectiles. In most cases, this secondary effect of the shockwave is by far more disruptive than the passage of the projectile, and a direct result of high kinetic energy. In low power projectiles like spears, arrows, knifes and darts, no such secondary effect exists - only the primary damage of the projectile's passage is relevant.

Poncelet published an equation that describes penetration long ago in 1850. In recent times the American Air Force Research Laboratory used this equation as bases for their work in maximum penetration depth. In 1996 at the *7th International Symposium Of Weapons Traumatology And Wound Ballistics* a paper was presented, and also published in the *Journal of Trauma-Injury Infection & Critical Care. 40(3S) Supplement:50S-52S, March 1996*. The authors developed a model to simulate a person, with and without protective armor, being subjected to an impact of a high speed, rigid projectile. Target resistance force was obtained from a generalized Poncelet equation. Good agreement between observed and computed penetration phenomena was obtained.

Dr. Ed Ashby published results indicating that arrow mass of about 650gr is needed to crush heavy bones, and that increasing the weight further did not greatly increase penetration. This result is predicted exactly by Poncelet, in that the equipment used by Ashby reaches a maximum predicted penetration using 650gr. and any further increase in arrow mass does not predict any deeper penetration.

This equation, SABA applied to archery, not with the purpose to calculate penetration, but for investigating the relationship between speed and weight and its correlation to penetration. The result of investigating penetration into **bone tissue**, showed a relationship between weight, speed and penetration that exactly mirrored weight x speed squared, or kinetic energy. The result for **soft tissue** was totally different and there the relationship closely resembled momentum: weight x speed to the power of 1.3, where momentum is of course weight x speed to the power of 1. This clearly demonstrates the reason why different

researchers favour different indicators (momentum vs. kinetic energy) as penetration indicators.

Bradly Hunt from Alkali International, published an article on AmmoGuide.COM called *A New Concept in Deep Penetration of Solid Rifle Bullets in Large Animals*. He describes a penetration index used in the big game hunting community where PA equals the square root of Kinetic Energy X Sectional Density / Frontal Area.
This immediately can lead to the false impression that they are using kinetic energy! In fact, in his own words, this equation can be shown through dimensional analysis to be identical to that of *momentum density*: Penetration Index = Momentum / Frontal Area. And finally, Dr. Ed Ashby with numerous and long term studies found penetration of arrows from traditional bows to be highly correlated to momentum.

Looking at this issue from the view point of physics, on first inspection when a mass is accelerated with a force, the energy transferred is the sum of the force at each point differentiated on the distance it travelled. In other words, the energy is what makes it possible to continue travel against a force. Or to put it even more simple, the force multiplied with the distance. Momentum is in fact very similar, but it looks at the force applied multiplied with the *time* it was applied. Energy looks at the force from the perspective of the distance, and momentum from the perspective of time. However, physics also defines energy is the ability to do work. According to physics, we must start from energy.

On deeper inspection, two things work against this simplistic model. The force that resists the movement for an arrow is proportional to its speed squared (friction between lubricated surfaces). This implies that the friction component of the force stopping the arrow, increases with the same rate as the energy increases if it's due to speed being increased!

The second complicating factor is "collisions". In physics all collisions are somewhere between purely elastic collisions (as when two billiard balls collide and bounce of each other), and non-elastic collisions (when two sticky balls collide and sticks together, traveling as one blob).
If you calculate the energy and momentum of the balls before and after the collision, you will find an odd difference between the two cases. During elastic collisions, kinetic energy and momentum is preserved, however during non-elastic collisions (when arrows "get stuck" in the animal) only momentum is preserved, and a certain amount of kinetic energy is lost.

When doing an experiment to test penetration, experiments are usually done in a homogenous medium like ballistic gel. For material that is the same all over, the amount of kinetic energy lost during such "collisions" are constant. Therefore a good correlation is found with kinetic energy. However, when doing this test with live animals, the amount of kinetic energy that is lost during each shot differs greatly and unpredictable. However, the momentum is not lost, and therefore shows a much better correlation to penetration.

Also if we look at Ashby's results more critically, he divided all the arrows into two groups. Those that penetrated the ribs and flesh thereafter, and those that was stopped by the ribs. After penetrating the bone (using kinetic energy), he measured penetration into flesh, where friction turns the correlation to momentum.

The problem with defining penetration ability (PA) recommendations is the great many factors influencing it, and the huge variation of penetration in different tissues by projectiles with marginal abilities. Factors affecting arrow penetration, excluding the tissue type, as found by the studies of for example Dr. Ed Ashby to have a high correlation, is momentum, and arrow design. In arrow design are included the number of blades, the angle of the blades, the cutting diameter, surface area, and the diameter of the shaft relative to the hunting point's shaft diameter.
In an effort to quantify all these measurements, Dr. Ashby suggests the use of a *tissue penetration index* (TPI = length/(BladeCount x Cutting diameter/2)).

This index captures most of the listed attributes, but excludes the effect of the general size of the hunting point (see next table). It also fails to provide for modern multi-blade hunting points with so called "bleeder blades."

If you alter just the blade height, you also alter the blade angle, or as discussed here, the blade length. The last factor, which we actually already quantified as blade angle, can also be understood in very simple terms. Short and wide blades tend to "chop" into flesh, while longer blades with a smaller cutting diameter tend to "cut" more. It is much easier to cut a steak by sliding a knife over it, than trying to push the knife through without any sliding movement.

And now we come to the broadhead's tip. There are even in something as simple as broadhead tip, many flavors and types. The decision on the tip is usually a compromise between penetration and durability. There are two major designs, cut-on-contact tips, and chisel-tips.

The chisel tips are very strong, and very robust. There are conical ones, square ones, triangles, and some have the flat areas of the tip machined out. The main advantage of these tips is their strength. You can break bones with them, and they will still have cutting edges to penetrate flesh thereafter.

FULL BLADES

L =BLADE LENGTH

H =BLADE HEIGHT

CD = Cutting Diameter

BLADE 1

BLADE 2

CUT ON CONTACT

L =BLADE LENGTH

H =BLADE HEIGHT

CD = Cutting Diameter

BLADE 1

BLADE 2

CHISEL POINT

L =BLADE LENGTH

H =BLADE HEIGHT

CD = Cutting Diameter

BLADE 1

BLADE 2
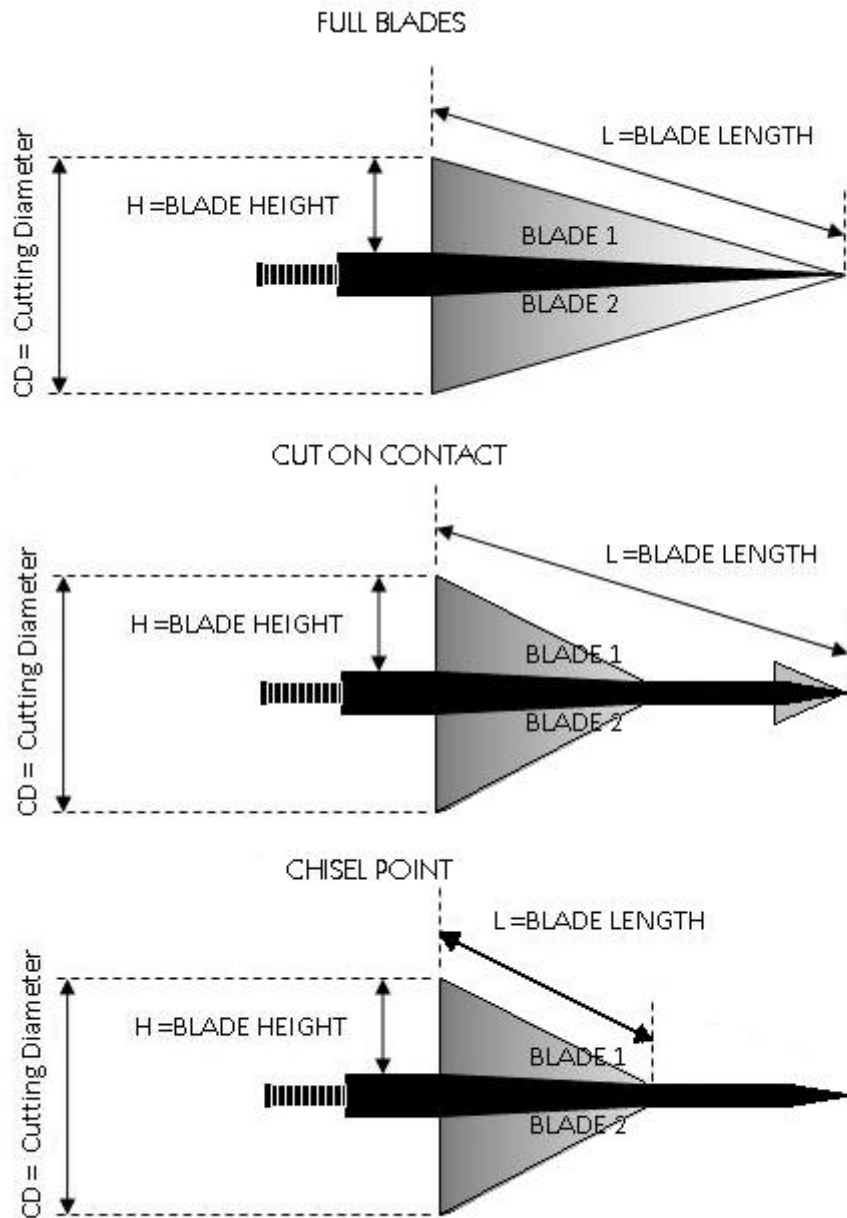
The cut-on-contact (coc) types are less durable, and may fail on hitting bone. However, their penetration in hide and flesh is by far superior to the chisel nose broadheads.

The difference in penetration can be demonstrated very easy. Put a rubber padding on a bathroom scale to receive the nock of an arrow, and push a piece of leather against the tip trying to measure the force needed to get penetration. Chisel nose tips frequently needs more than 20 pounds of force to penetrate into a piece of deer skin leather, while coc tips may need as little as 2 pounds of force for complete penetration. So if you are sure about shot placement (which you actually should be), coc tips do wonders; if you are afraid of leg bones, the chisel nose tips are better.

Another idea that can be pushed too far is to make the blade VERY long, like for example 3 or more inches. The question that comes up then is when does the surface friction of this long blade cancel the advantage of the very low blade angle?

You must remember that all animals are very heterogeneous, and consists of very hard bones, very tough sinews, muscles that move across the arrow's path, and right at the other end of the scale, tissue that is largely just airbags (lungs and genuine airbags in birds). The ability of an arrow to penetrate these is dependent on the arrow's mass and its speed. The importance of mass vs. speed changes as the hardness of the material changes. For some materials kinetic energy, where speed is much more important than mass, will be indicative. For other materials, speed plays a relatively small role in relation to mass.

If we look at the VERY heavy caliber hunting rifles, used for the real LARGE animals, penetration of 2 meters can be attained, and the best indicator thereof is *momentum density*. This very much underlines SABA's recommendation to focus on momentum, as mass and speed, to be used as primary indicator of penetration ability.

But let us look at the broadhead blades in more detail. I guess you would not easily catch a bowhunter reading articles on kitchen practices, but one particular subject is very relevant - how much force does it take to cut meat with a knife? Apparently, for somebody doing this job for a life, it means quite a lot. Anyway, the answer is relevant to broadheads too. Using very sophisticated equipment (no, really!), they measured this force to be proportional to the tangent of half the angle between the blade, and the direction it travels. The exact value is not surprisingly influenced by the cut's direction in relation to the muscle fibers, and how tough the meat is. Values like 10 to 20lbs per inch across the grain are typical. (In experiments we describe later, a value of 8lbs/inch was measured, but do notice we were cutting with the grain.) This force can also be called the cutting resistance (R), and it is mathematically much easier to work with this resistance, rather than ease of penetration (its inverse).

The cutting force is directly proportional to the *tan* of half of the angle of the blade to the direction of the cut: *tan*(A/2). This value can be approximated to a fair degree using the Sin of the full angle, or exactly as Dr. Ashby reported, the cutting length of the blade divided with the blade height. A more accurate way to calculate it is to use the height squared and then divided with the length of the blade's edge added to the length of the blade's base. This relationship is also applicable to the angle used to sharpen the blade at, and the angle at which chisel points are made.

Further Reading: Cleve Cheney, **AB**, Jan/Feb 2001, p24, *"Arrow penetration – Is there more to it than kinetic energy and momentum?"*

3.1.1   Penetration Index – A new formula

In an effort by SABA to define a more comprehensive index, a new formula is suggested. Herein the following assumptions are made about the hunting point:

1) The larger the point size (cutting diameter), the more difficult it will penetrate,

2) The larger the angle of the blades with the shaft, the more difficult it will penetrate (reaching a maximum at 90°),

3) The more blades it has, the more difficult it will penetrate.
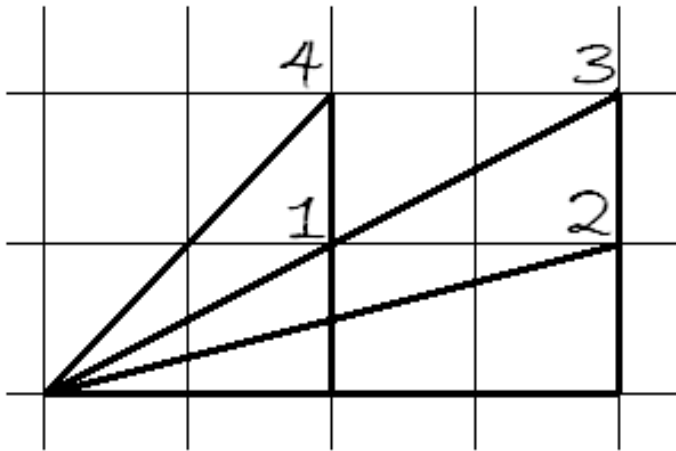
Going from #1 to #2, you would expect the force needed to cut flesh to half, from #1 to #3, it should double, and from #3 to #4 it should also about double (or be about 4x that of #1). Using the relationship of $H.tan(A/2)$, which is the same as $H^2/(L+x)$, where x is the length of the blade along the shaft, we can see this pattern, except for #4,

which results in just more than 3.5x the force needed than for #1. For our purposes it will suffice.

$H^2/(L+X)$	Blade Lenght				
	0.8	1	1.2	1.4	1.6
0.35	0.16	0.13	0.10	0.09	0.08
0.40	0.21	0.17	0.14	0.12	0.10
0.45	0.28	0.21	0.18	0.15	0.13
0.50	0.35	0.27	0.22	0.18	0.16
0.55	0.44	0.33	0.27	0.23	0.20
0.60	0.54	0.40	0.32	0.27	0.23
0.65	0.67	0.48	0.38	0.32	0.28
0.70	0.83	0.57	0.45	0.38	0.32

(Blade Height on vertical axis)

If you look at the table below (made with the $Tan(^A/_2)$ principle), you will see that increasing the blade length (changing from blade #1 to blade #2 as in the above picture), reduces the force needed to cut (going right on any row). I.e. double the blade length, and the force needed is halved.

When going from #1 to #3, as in the above picture, you can see that what we did was in effect to add another blade - doubling the force needed. This you can follow in the table below by travelling diagonally to the right and down.

And lastly going from #1 to #4, you can see we doubled the blade height and the angle, so the resistance or cutting force needed almost quadrupled. This you can follow in the table by dropping down straight in each column. The resistance of each blade is theoretically proportional to $H^2/(L+x)$, or its height multiplied with itself, divided with sum of the length of the cutting side and the shaft's

side. This index directly mirrors the tangent rule as measured with knifes. (It is also an extension of Ashby's method, which employs H/L, but which is insensitive of changes from #1 to #3).

The cutting resistance of the whole broadhead then becomes the sum of all the blades' resistances. For example, taking a two bladed broadhead with a cutting diameter of 1", and blade lengths of 1", each blade's resistance index is 0.063, and the total blade resistance is then 0.13.
(Keep in mind we are talking about resistance here, and want a small as possible value.)

A table of various blade designs is provided highlighting the sensitivity and variation in this index:

Blades	CD	L	CD(mm)	L(mm)	H(mm)	TPI	$H^2/(L+x)$

The first 3 rows increase the cutting diameter. The new factor is slightly more critical of cutting diameter than TPI.

Blades	CD	L	CD(mm)	L(mm)	H(mm)	TPI	$H^2/(L+x)$
2	1	1	25.4	25.4	8.9	1.00	1.00
2	1.25	1	31.75	25.4	12.1	0.80	0.71
2	1.5	1	38.1	25.4	15.2	0.67	0.54

In these 3 rows we only increase cutting blade length. Same as TPI.

2	1	1	25.4	25.4	8.9	1.00	1.00
2	1	1.25	25.4	31.75	8.9	1.25	1.26
2	1	1.5	25.4	38.1	8.9	1.50	1.53

In these 3 rows we only increase the number of blades. Same as TPI.

2	1	1	25.4	25.4	8.9	1.00	1.00
3	1	1	25.4	25.4	8.9	0.67	0.67
4	1	1	25.4	25.4	8.9	0.50	0.50

In these 3 rows we increase the overall size of the broadhead. PI is sensitive to size while TPI is not.

2	1	1	25.4	25.4	8.89	1.00	1.00
2	1.25	1.25	31.75	31.75	12.07	1.00	0.91
2	1.5	1.5	38.1	38.1	15.24	1.00	0.86

CD: cutting diameter, L: Blade length, H: Blade height
Please note that $H^2/(L+x)$ were adjusted to the same scale as TPI in order to compare their sensitivity.

But what about the tip? We can again employ the tangent rule where the more acute the angle of the point, the less force is needed to cut and push the flesh away. A 45° chisel would for example thereby penetrate 2.4x deeper than a flat point. Cut-on-contact tips (where the broadhead has a blade at its tip) can then be presented with two angles, one for the tip angle (usually about 60°) and the other for the edge angle (usually about 20°). So the tip's resistance becomes something like $k.Diameter^2.Tan(^A/_2)$, where we still have no idea what the value of k is. Now we have a total blade resistance, and a tip resistance. But how do these relate together to penetration?

The force needed to penetrate is of course directly related to the resistance the point feels when penetrating. A formula was derived from experimental data that best describes the relationship between the dimensions of the blades, the tip, and the resistance:

$$R_0 = 44((S_t \cdot \tan(\frac{A_t}{2}) \cdot \tan(\frac{A_{ts}}{2}))^{0.5} + \sum H^2/(L+x) \cdot \tan(A_s/2))$$

S_t is the frontal surface area of the tip,
A_t the angle of the tip,
A_s the blade's sharpened angle,
H the blade's height,
L the length of the cutting edge
A_{ts}, is A_t for chisel points and A_s for cut on contact points, and the result is in pounds. The resistance (R_o) is also the resistance at very slow speeds of penetration - from there the zero on its toe. For how this relates to resistance at speed, read on...

Measured
Predicted

12 10 8 6 4 2 0

FP1 FP1 N0 Ma0 Mb0 N1 N2 N3 Ma3 Mb3 R
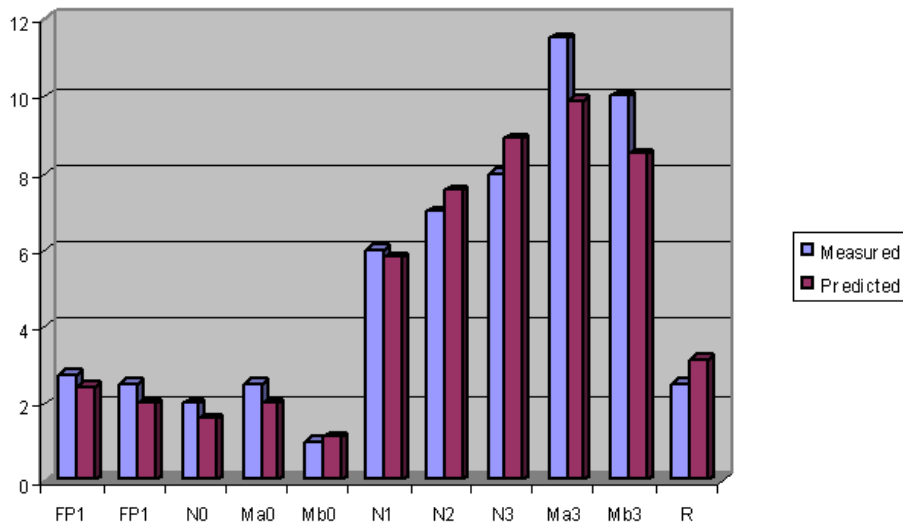
This equation predicts how much resistance a broadhead of a particular design
will experience when pushed through muscle tissue very slowly. The graph on the
left is of predictions compared to actual measurements. This was for 2 different
fieldpoints, a Nitron with no blades, a chisel point mechanical with no blades,
a cut-on-contact mechanical with no blades, a Nitron with 1,2 and 3 blades, the
mechanical with chisel tip and 3 blades, the c-o-c mechanic with its blades, and
lastly a Razor Back 2 bladed c-o-c broad head.

So as a recap, we now are able to relate the blade's design directly to its
resistance to penetration. But we are still looking at the force needed to
penetrate. We are actually interested in how deep it will penetrate.

To calculate this we may want to start with kinetic energy, and divide it with
the resistance it experiences during penetration: $D = E_k/R_o$, as is done using
the basic laws of Newton. But this is where most kinetic energy disciples make a
fundamental error. This is only valid if the resistance was constant, and in
our case it is not. According to this erroneous assumption a 400gr arrow @
280fps (70vt.lbs), with the R_o = 2.75 + 0.5 pound fieldpoint, would penetrate
257 inches (yes, hundreds). The Nitron would go about 104"! But these numbers
are "slightly" too big, because the resistance we used is from slow penetration,
and ignores the effect speed has on friction.

In (Oct 2009) *The Bowhunter* magazine, it was discussed that friction is
proportional to the speed squared (v^2). From our reasoning so far we can also
approximate that it will be proportional to the force needed to push the
broadhead slowly through the medium, plus a so called *drag factor*. This drag
factor is also called the skin friction, and grows with the speed squared. It is
also proportional to the surface area of the broadhead and shaft that is in
contact with the target. Lastly it contains a "form factor" that captures the
effect of the form. For this form factor, we can use an approximation or an
already known factor, that should follow it closely, the R_o.

For this growing resistance we will use $R_o + (R_o.A + a)v^2$.

Blade Height 0.4

Blade Length 0.7"

BH	BL
0.4	0.7
0.4	0.7
0.4	0.7

PI = 0.684

1.0"   0.3"

2.5"

BH	BL
0.35	2.5
0.35	2.5
0.3	1.0
0.3	1.0

PI=0.995

0.35"

1.5"

0.41"

BH	BL
0.41	1.5
0.41	1.5
0.41	1.5

PI=0.890

0.4"

1.25"

BH	BL
0.4	1.25
0.4	1.25
0.4	1.25

PI=0.847

0.7"

0.35"

BH	BL
0.35	0.7
0.35	0.7
0.35	0.7
0.35	0.7

PI=0.679
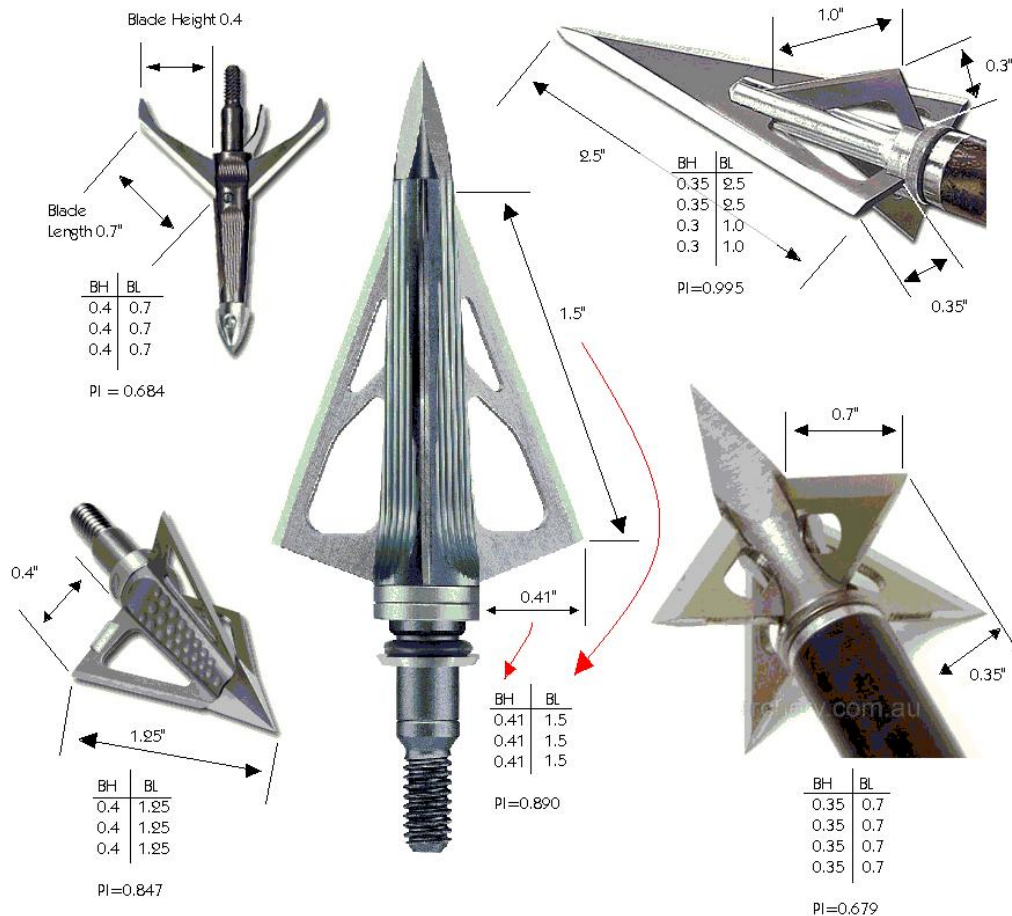
The surface area for the broadhead is **A**, while the surface area for the shaft is **a**. Note that R_O is applied as form factor only to the surface area of the broadhead, as the form of the shaft for all arrows is constant, and not related to it.

Here is the function developed for MicroSoft Excel:

```
Function PDepth( _
    ByVal Ro As Double, _
    ByVal m As Double, _
    ByVal v As Double, _
    ByVal dia As Double, _
    ByVal a As Double, _
    ByVal ds As Double, _
    ByVal c1 As Double, _
    ByVal c2 As Double, _
    ByVal c3 As Double, _
    ByVal KELoss1 As Double, _
    ByVal BodyDepth As Double, _
    ByVal KELoss2 As Double)

    Dim s As Double, d As Double, PI As Double, KE As Double, vv As Double
    PDepth = "err"
    PI = 3.141592654

    s = 0 'initialize distance penetrated
    If Ro < 2 Then Exit Function 'too little Ro, model will crash
    If ds <= 0 Then ds = 0.001 '1 mm steps

    'limits the minimum speed to about 140 fps
    v = v - ((c1 / v) ^ c2 - 1)
    If v < 0 Then Exit Function

    'SI units
    Ro = Ro / 2.2 * 9.8 'lbs to Newton
    m = m * 0.065 / 1000 'grains to kilogram
    v = v * 12 * 2.54 / 100 'fps to meter per second
    dia = PI * dia * 2.54 / 100 'shaft dia in inches to shaft area in
                                'meter squared per meter shaft
    a = a / 1550.0031 'inches squared to meter squared
    BodyDepth = BodyDepth * 2.54 / 100 'inches to m
    KELoss1 = KELoss1 * 1.359431604   'foot pounds to J
    KELoss2 = KELoss2 * 1.359431604   'foot pounds to J

    If KELoss1 > 0 Then 'modeling bone penetration as loss of energy
```

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```
        ' this is valid as penetration into bone is related to KE
            KE = m * v ^ 2 / 2
            KE = KE - KELoss1
            If KE < 0 Then Exit Function  'if we don't get through the bone, done
            v = (KE * 2 / m) ^ 0.5 'get the speed exiting at back of bone
        End If

        vv = v ^ 2  'meter per second squared - we will loop using vv
        s = 0
        Dim aa As Double
        Do While vv > 1 And s < 10
            If s > BodyDepth + 0.75 Then        ' [       ] ------------->
                Ro = 0
                a = 0
                aa = 0
                PDepth = 999
                Exit Function
            ElseIf s > BodyDepth And s > 0.75 Then ' [   ----]------->
                aa = (0.75 - (s - BodyDepth)) * dia
                a = 0
                Ro = 0
            ElseIf s > BodyDepth Then           '    --[-------]--->
                aa = BodyDepth * dia
                a = 0
                Ro = 0
                If KELoss2 > 0 Then  ''exit rib breakage energy loss
                    KE = m * vv / 2 - KELoss2
                    'if we don't get through the bone, done
                    If KE < 0 Then exit do     '    --[-------]
                    vv = (KE * 2 / m)
                    KELoss2 = 0
                End If
            ElseIf s > 0.75 Then            '    [ ------------>      ]
                aa = 0.75 * dia
            Else                        ' ------[----> ]
                aa = s * dia
            End If
            d = (Ro + (Ro * a + aa) * vv) / m
            vv = vv - 2 * d * ds
            s = s + ds
        Loop
        If s >= 10 Then
            PDepth = 999
        Else
            PDepth = s * 100 / 2.54 'and return the result in inches
        End If
End Function
```

A similar modal was previously used by the author to predict the trajectory of an arrow through the air, based on this same friction principle. The friction (F_r) the arrow experiences at various speeds changes, so it also changes as the arrow decelerates during penetration. This model involved simulating the arrow's path in small steps, and to calculate the friction at each step. But it requires a "friction constant" (k). For the trajectory we could calculate k using two measurements, at 1Y and 20Y, and adjusting k until it predicted the same speeds as measured.

With penetration this is a bit problematic, since there doesn't exist a reliable measurement of penetration. So we will have to make use of "experience" to tell us if it works or not. So far the best recorded experience we have is of Dr. Ashby's research. He found that between kinetic energy and momentum, the latter showed a better correlation to penetration. Likewise, Poncelet predicts theoretically a relationship of $mv^{1.4}$. This is about halfway between momentum and KE, just slightly closer to momentum.

Any IT-developers looking at the code, will notice that the current model does NOT contain any constants that "scales" the results into "acceptable" values. In fact rather the opposite, we have an arbitrary factor that *increases* the speed. The reason for this is that the speeds at which adequate penatration is achieved, is much less than what you would hunt at - due to string jumping and arrow deflection issues.

In this model, we decided to make k=1, and see what happens. To our surprise, the model predicts that for penetration into soft tissue, the relative importance of mass to speed of the arrow is 1:0.998. I think you will agree with me this is as close to 1:1 as a Robin Hood is to a nice grouping.

On the next page is an extract of some penetration predictions (in inches) of the model

In this case we used a typical mechanical broadhead (3 blades). We also did not

hit bone on entry, and the soft tissue is always deeper than the penetration. If we put a "real" animal in the model, this time an impala, the model makes suggestions as below.
Here we see it asks 250fps for a 300gr arrow to stop against the far side rib. This is by the way why you see such interesting values. All arrows seem to have either too little penetration, enough to be stopped by the far side rib (8"), or enough for a total pass through (999.0). As mentioned earlier, it is much more difficult to break the far side rib than the rib on entry.

Arrow speed (fps) — Penetration (depth)

Arrow weight (grains)	150	175	200	225	250	275	300	325	350
300	8.4	10.4	12.3	13.9	15.4	16.8	18.1	19.3	20.4
350	9.8	12.2	14.3	16.1	17.9	19.4	20.9	22.2	23.5
400	11.2	13.8	16.2	18.3	20.3	22.1	23.7	25.2	26.6
450	12.6	15.5	18.1	20.6	22.7	24.6	26.5	28.1	29.6
500	13.9	17.2	20.1	22.7	25.0	27.2	29.1	30.9	32.6
550	15.3	18.8	22.0	24.8	27.4	29.7	31.8	33.7	35.6
600	16.6	20.5	23.9	26.9	29.7	32.2	34.4	36.5	38.5
700	19.3	23.7	27.6	31.1	34.2	37.0	39.7	42.1	44.3
800	21.9	26.9	31.3	35.2	38.7	41.9	44.8	47.6	50.1
900	24.6	30.1	34.9	39.3	43.2	46.7	50.0	53.1	55.9
1050	28.5	34.8	40.4	45.3	49.8	54.0	57.8	61.3	64.6
1200	32.3	39.4	45.7	51.3	56.5	61.2	65.5	69.5	73.3
1350	36.1	44.1	51.1	57.4	63.1	68.3	73.2	77.7	81.9

Arrow Speed (fps) — Impala model

Arrow weight (grains)	150	175	200	225	250	275	300	325	350
300	err	err	err	5.7	8.0	8.0	8.0	999.0	999.0
350	err	err	err	7.9	8.0	8.0	999.0	999.0	999.0
400	err	err	err	8.0	8.0	999.0	999.0	999.0	999.0
450	err	err	err	8.0	999.0	999.0	999.0	999.0	999.0
500	err	err	err	8.0	999.0	999.0	999.0	999.0	999.0
550	err	err	err	8.0	999.0	999.0	999.0	999.0	999.0
600	err	err	err	8.0	999.0	999.0	999.0	999.0	999.0
700	err	err	err	999.0	999.0	999.0	999.0	999.0	999.0
800	err	err	err	999.0	999.0	999.0	999.0	999.0	999.0
900	err	err	1.1	999.0	999.0	999.0	999.0	999.0	999.0
1050	err	err	3.6	999.0	999.0	999.0	999.0	999.0	999.0
1200	err	err	6.0	999.0	999.0	999.0	999.0	999.0	999.0
1350	err	err	8.0	999.0	999.0	999.0	999.0	999.0	999.0

Footpounds
- less than 40
- 40-50
- 50-60
- 60-70
- 70-80
- 80-110
- more than 110

The colours in the above table are indicative of kinetic energy.

But this is ALL only valid, IF THE ARROW NEVER TOUCHES A BONE!

How does these broadheads penetrate bone? It takes about 260 foot-pounds to break a human leg bone, 65 foot-pounds to break an arm bone, and 22 foot-pounds for a rib. This information is from forensic tests and quite reliable. As you can see, a bone as big as your leg bone should stop ANY arrow, an arm bone will

severely slow the arrow down (200fps loss for a 750gr arrow) if not stop it, and
a rib will generally decrease penetration.

Speed loss for breaking rib on entry: (20 foot-pounds loss)

	300	500	700	
200	-100	-52	-35	As you can see, slower and lighter
225	-81	-44	-31	arrows looses more speed breaking
250	-70	-39	-27	ribs than faster and heaver ones.
275	-61	-35	-24	
300	-55	-32	-22	

For the purpose to standardize energy loss and penetration, we propose the
kinetic energy loss (foot ponds) be calculated as the animals weight (in kg)
raised to the power of 0.25, multiplied with 4.5.

Approximation of energy needed to break a rib per animal mass:

Animal weight	energy needed
50	12
100	14
200	17
350	19
500	21
750	24
1000	25
2000	30

Another interesting prediction we see is: when we take two arrows, weighting
900gr @ 200fps and 300gr @ 345 fps (both have kinetic energy 80vt.lbs) and say
both break a 25 footpound rib on entry, the 900gr arrow looses 18% of its
penetration, and the 300gr arrow only 13.4%. However, the 900gr arrow still out
penetrates the 300gr one by more than 50%.

But we are now loosing focus and are trying to define penetration in terms of
the target being hit, and not the broadhead. Although this is the reality of
hunting, the heterogeneity and all variables of a live animal being penetrated
by an arrow, is totally impossible to predict. Instead we limit ourselves to
muscle tissue, and the effect of a single rib on entry and exit. In other words,
we standardize the animal.

Warning: Although tests like these try to prove heavier arrows have more
penetration, they rather reflect that the bow is slightly more efficient at
higher arrow weights. The medium is not comparable to wet tissue, but is
indicative of penetration into bone.

What we do know is that penetration into bone is proportional to kinetic
energy. The first observation is that most cut-on-contact point tends to bend
when hitting bone. This **severely** inhibits penetration. The next observation is
that blades that are beveled from a single side, tends to split the bone
easier, and thereby penetrates better. Thin blades, as for example bleeder
blades, tend to break when big game is hunted. Ashby reported what he calls a

tanto tip to be most effective on traditional equipment. Of course, chisel tips
are extremely strong, and rarely are damaged.
And when a broadhead breaks, it stops penetrations like a brick wall...

Lastly, we ask can a hunting point have too much penetration ability? Yes. We
also propose recommendations on the minimum size of hunting points. This
stresses the fact that a too small hunting point becomes a field point, which
in essence minimizes systemic damage, and will prolong the bleeding time of the
animal. So we clearly see that there is a need for proposed minimum and maximum
sizes of hunting points. Also it is of no use putting lots of energy into the
arrow, only for it to cut a small channel, and then to fly of another 300Y into
the distance... At best, a broadhead should use most of its energy to cut, and
only fall out of the animal at the other side...

Further Reading: Cleve Cheney, **AB&A**, Apr 2007, p27, *"What is TPI?"*

3.1.2   A Case Study on Friction

According to tribology (the scientific study of friction):

- Friction against "dry" hard surfaces are dependent only on the type of
  surface, and the force pushing them together. At low speeds, friction is
  independent of the relative surface speed. At higher velocities the
  friction actually decreases!
- Friction in fluids (air and liquids) is dependent on the viscosity of the
  fluid, the shape of the object, and the speed. If the speed
  is "relatively" slow, and no turbulence occurs, the friction is
  proportional to the speed, but if turbulence occurs (like an arrow
  traveling through air, water or oil), it is proportional to the speed
  squared.
- For lubricated surfaces the friction is almost independent of the force
  between the surfaces. At low pressures the friction varies directly as the
  relative surface speed. Above 2 fps the friction rises in proportion the
  velocity squared.

Animals consist of a mixture of solids (bone), elastics (hide, sinew, muscle)
and liquids (water and oils). Fats are "oil-lubricated solids". So perhaps it's
best if we look at lubricated hard surfaces and fluids. So for liquids, to the
best approximation, the arrow feels friction relative to its speed squared. This
is a force, which decelerates the arrow in relation to its mass: Deceleration =
Force/mass. The distance travelled during such a deceleration is according to
Newton $s = \frac{1}{2}.m.v^2 / F_r$. Notice how close this formula looks like that for
Kinetic energy, but do not be tempted yet. The friction (F_r) is also
proportional to the speed squared!

So penetration becomes proportional to somewhere between $m.v^2/v$, and $m.v^2/v^2$!
Which means that at one end of the spectrum penetration is related to momentum
(mv), and at the other end, only mass, for lubricated surfaces. Whow! So what
happened to kinetic energy?

Poncelet's formula takes the target's hardness (which resists breaking) and
density (which resists pushing the broken fragments out of the way) into
account. It shows us how the relative importance of speed falls as we shoot into
flesh rather than bone. Here we also see that friction favours mass over
velocity when shooting into flesh.

So in effect, the relative importance of arrow weight and arrow speed, as
indicator of penetration, is dependent on the type of material you shoot into.
We can look at his problem totally pragmatic. In order for an arrow to penetrate
a hard, thin substance, there is no friction involved, since it is not yet
passing through, it has only just arrived. Pushing the hole in the object, and
travelling into the hole is two different things.

On one of the discussion forums for Bowhunting, Anchor Point, a member reported
strange findings ("BoogSkutter"):
Poundage: 66lbs
Broadhead: Nitron 100gn

Fletches: 4 inch plastic vanes
Arrow A: Gold Tip 5575
Arrow B: Easton 340
Arrow C: Carbon Express Terminator 6075
BoogSkutter also used the same broadhead on all the arrows, so sharpness and
bent blades etc. were eliminated as influences.

Results: The Easton (422 grn) and the Gold Tip (370gr) penetrated deeper than
the Carbon Express (458gr). Which throws things on their head it would seem.

Now, lets look at all the attributes of these arrows closely:

	gr	Dia.	Spine	gpi	FOC	Fc%	fps	KE	cP
Gold Tip	370	0.295	400	8.5	11	44	192	70	48
Easton	422	0.294	340	10.5	9.6	53	277	72	52
CarbExp	458	0.315	350	11.8	8.9	52	268	73	55

Fc% is the critical loading weight of the arrow as a percentage of the bow's
draw weight, and is an indication of dynamic spine - values between 38% and 45%
is generally good (45 being the stiffest). (The definition of these attributes
is discussed later in full detail.) KE is kinetic energy and cP is the momentum
x100. So how can we explain the above anomaly, where both KE and cP is largest
for the Carbon Express arrow, but it penetrated the least?

When stating that heavier arrows penetrate better than lighter one, we are
assuming that all other variables stay the same. For these three arrows, not
only the weight changed, but the diameter, the spine, and the FOC. This caused
changes in for example dynamic spine, Fc%. The Gold Tip arrow is slightly on the
stiff side, but still in the green. The other two arrows are outside the range -
too stiff. Which would in general mean that the bow is slightly less efficient
than it should be, and the arrows are probably going to wobble a bit. However,
since the Easton penetrated the deepest, this can't explain the result. If we
look at the momentum of the arrows, we also see that the Carbon Express, with
the most momentum, penetrated the least. Again, it does not explain the results.
The key is however the diameter of the arrows.

When big game rifle hunters talk about penetration, they talk about
momentum-density. This is the momentum divided with the frontal surface area of
the projectile.
Have a look at these values:

	Dia	cP	Frontal Area	cP density
Gold Tip	0.295	48	0.068	7.022
Easton	0.294	52	0.068	7.651
CarbExp	0.315	55	0.078	6.996

If we now look at the cP density, it explains why the Easton did the best. If we
took the FOC and dynamic spine into account, it also explains why the GoldTip
did 2nd best. But, these experiments were done in a cardboard box butt. What
effect would this have had? The tribologists would be tempted to say that since
the friction area's were dry, the pressure on the bigger shafts was more and
faster speeds had slightly less friction, and so the Easton won. They would also
claim that if hunters shoot at flesh, friction is independent of surface
pressure, but goes up with speed squared. So in flesh, the Carbon Express would
have won.

The last point I would like to make on friction, is that there is even a
difference between shooting a live animal versus shooting into meat. Not only
does the temperature change the viscosity of the oils and fats, but in live
tissue, the muscle movement and tension pulls the muscle away from the arrow, if
the muscle is pulling against something. If the muscle is not pulling against
something, as when a leg is in the air, it can do the opposite, and pinches the
arrow. Friction therefore in live animals is not that prominent in these
recommendations.

Having said all this, with the intention to indicate the subtleties of friction,
how does it tie in with our recommended PA? The depth to which the arrow
penetrates is highly dependent on
1) the amount of energy the arrow reaches the target with,
2) the energy needed to cut the hole,
3) the energy needed to push the arrow deeper through the hole,
4) and the energy needed to push the cut flesh out of the way of the shaft.
The PA as described only addresses the "cutting the hole" part, and not the

friction to push it through, nor pushing the flesh away. In fact, it is this very friction which "downgrades" the value of kinetic energy to momentum. Likewise, at speeds of 285km per hour(!!!), or around 260fps, a typical hunting arrow's speed, you can probably, with only your big tow, ski on water! Which illustrate the substantial amount of force needed to move flesh out of the way!

3.1.3   Front of Center

Other factors influencing penetration of projectiles are sectional density and the centre of gravity of the arrow (FOC). Sectional density is the mass of an object divided with it frontal surface area. Sectional density does play a major role in arrow penetration, since the difference in arrow shaft weight. However, the differences in diameter are usually very small. However, new technology are decreasing arrow diameter, and this will need to be revised.

FOC, or Front Of centre, is a term describing how far the centre of gravity of the arrow is in front of the middle of the arrow. This value is usually between 5% and 12% for target shooting, and 8% to 15% for hunting arrows. The FOC is in effect an indication of the flight stability of the arrow.

Where it plays a role in penetration is easiest to picture if an arrow is imagined that hits a target slightly at an angle. Such an arrow's momentum, acting through its centre of gravity, will push the point sideways and greatly reduce penetration. For this reason a higher FOC makes the bowhunter's set-up more forgiving for a slightly less than perfect arrow flight. This is in fact the same reason an immediate unease was felt about using a spear to hunt an elephant, as described elsewhere.

The FOC and total length of the projectile also defines the distance of this centre of gravity from the impact point. A spear, although it may have a higher kinetic energy, momentum and sectional density, has a much longer shaft. This means the point is driven by momentum from a much further distance, which greatly increases the leverage that will skew the penetrating projectile and greatly reduces penetration. In general, the further forward the centre of gravity is to the *centre of pressure*, the more stable the arrow is. Now the reason for having a stable arrow is simple, it affects accuracy, and penetration.

In archery terms we speak of the *FOC* of an arrow, which is a term to describe the position of the centre of gravity, relative to the centre of the arrow. It does not take the centre of pressure into account. FOC is calculated by first

measuring the distance between the middle of the arrow, and the point on which it balances, then divide it with the total length of the arrow.

The lower the value, the less stable the arrow, but also the trajectory is slightly more flatter. The arrow glides more. The bigger the value, the more stable the arrow, but the quicker it loses height. It glides less, and looses less speed over the trajectory.

The higher the FOC, the longer the lever that the fletching has to steer the arrow, and the shorter the lever for the broadhead to steer it.

Centre of pressure, can easiest be measured by sitting in your car, while someone else is driving, while you hold the arrow out of the window. If you turn it sideways in the wind, you will notice the wind pushing against it, trying to turn it either point forward or tail forward. Somewhere along the shaft you'll find a point where the wind's push on the arrow's tail and point is balanced. This is the *centre of pressure*.

A more accurate indication of stability of an arrow is the distance between the centre of gravity and this centre of pressure, divided by the length of the arrow. But since driving around with your arm out of the window, holding an arrow, can pose some serious safety hazards to pedestrians, FOC do quite well.

To calculate it, you first measure the distance from the nock's string hole, to the centre of gravity, say this is 17". Then you measure the total length of the shaft, from the nock's string hole to the insert in front of the shaft, say this is 29". The FOC is now balance point length/total length - 0.5, multiplied with 100:
    (17/29 - 0.5) x 100 = 8.6%

The effect FOC has on penetration is threefold. Firstly it stabilizes the arrow for good flight, leading to a arrow that hits the animal without any vibrations. This causes better penetration, since the mass that is pushing the arrow from its centre of gravity, is centered exactly behind the broadhead.

Secondly, the moment the arrow hits the animal, a force is generated against the arrow that decelerates it. The higher the FOC, the shorter the lever this force has to tilt the arrow and negate all its momentum.
Thirdly, since the arrow can when hitting an animal, stops in the same distance it was accelerated to its flight speed, this force can be as big as the bow's draw weight. Buckling/bending of the arrow is therefore just as prevalent during penetration as during release. This bending will also affect penetration for again the penetration force is tilted away from the broadhead. The larger the FOC, the bigger the force that can be withstood by the shaft, since the bending force between the broadhead and the centre of gravity, is applied on a shorter piece of the shaft.

Finger shooters, and those shooting shafts less than 26 inches in length, should probably look for a higher FOC. This is because shorter arrows are inherently less stable, and finger shooters, once again, need a little extra help to correct the normal arrow wobble upon release.

Too much FOC, according to folk legend, makes your arrows point-heavy and causes them to drop quicker at long ranges. However flight-

archery, where the aim is to shoot as far as possible, is breaking records with high FOC arrows! It does not affect arrow speed, in fact it preserves long range speed better. However, as hunting is not recommended at these long distances, it should not be a problem. Dr. Ed Ashby reports on what he calls *extreme* FOC penetration. These are arrows with a FOC above 15%, typically 20%. For these arrows he measured increases in penetration on buffalo of between 20% and 60%.

We can provide an empirical formula for his results, and it looks like this:
FOC's contribution = $0.55 * FOC^9 / ((36 - FOC)^9 + FOC^9) + 1$
This equation just follows a smooth path to effect the results Ashby saw in relation to FOC.

FOC and dynamic spine very much affect each other directly. The bigger the FOC, the bigger the buckling force the arrow experiences during release, and you will have to check that the critical loading of the arrow does not drop below 38% of the bow's draw weight.

If you are wondering what an arrow's FOC will be, but have not yet built it, you can use the following equation to calculate it:

$$FOC = 100 \cdot \left(\frac{\sum W_i \cdot L_i}{L \cdot W_t} - 0.5 \right)$$

where W_t is the total arrow weight,
   W_i is the weight of each component,
   L is the length of the arrow, and
   L_i is the distance of the component's center of gravity from the nock point.

Further Reading: Seppie Celliers, **AB&A**, Apr 2008, p30, *"FOC – Front of centre balance"*
JP de Villiers, **AB&A**, Feb 2008, p58, *"FAQ's"*
Dave Holt, **AB**, Nov/Dec 2000, p7, *"Arrows – Heavy versus light"*
Dave Holt, **AB**, Mar/Apr 2001, p9, *"The Downrange decay of Arrow Velocity"*
Herman Brand, **AB&A**, Dec 2007, p51, *"Swaar of Ligte Jagpyle?"*

3.1.4   Shaft Diameter

The shaft of the arrow experiences friction during penetration, and as such affects it. Experimental results have shown that an additional factor can be multiplied with the achieved velocity or momentum, to accommodate this influence. This shaft factor is based on whether the shaft of the arrow is the same size or larger than the hunting point's ferrule's diameter. If the arrow's shaft is the same size, a shaft factor of 0.9 should be used, while if the arrow shaft is larger, a value of 0.6 should be used (if smaller 1.0).

3.1.5   Shaft Tilt

The model we are trying to develop has at its hart defining penetration in terms of the arrow's attributes. But some of these attributes are not independent of the target, for example the R_O defined elsewhere, which is a function of the blade design **and** the type of material being penetrated. As such, we had to standardize on some sensible medium. In looking at the effect of arrow tilt, we are delving into even harder ground.

Ignoring this effect, leaves the model still accurate for shallow penetrations, but less so when more of the shaft is involved.

The specific influence we are trying to discuss here is when an arrow hits a moveable, moving, and gel like material, like flesh, the bending or tilted arrow deflects, pushes against the wound channel, and in general tend to change direction. Elsewhere it is suggested not to shoot across the wind, since the arrow's tail is blown sideways by the wind, and for an arrow to hit the target at an angle severely effects penetration. But how much, and what attribute of an arrow works to minimize this effect?

At the same time, an arrow that hits a target, is decelerated over a similar distance and time than when being released. It is therefore not surprising that it flexes, bends, tilts, and generally gets pushed away from its original flight path.

Terminal ballistics of rifle bullets that comes closest to this problem is when the projectile tumbles due to becoming instable upon entering flesh. With bullets, this tendency is a function of the center of gravity relative to the *center of pressure*. But by now you would recognize this as being approximated by FOC.

Let's look at this problem from the viewpoint of a crosswind. An arrow at 250fps is traveling at 275km/h. A crosswind of 20km/h sounds insignificant, or does it? The arrow will tilt just about 4.2 degrees to its flight path. This means the arrow's point of contact will be 2" to the side of the nock. How will this influence penetration?

If we revisited the effects seen due to the angle of a blade, where the force needed to cut is proportional to tan of half the angle, we see this factor for a blade hitting square on is 1, and it diminshes to zero when the blade slides parallel to the cut. An arrow hitting perfectly inline penetrates the deepest. One hitting flat will of course not penetrate at all. The angle changes from 0 to 90 degrees. At small angles the effect will be small, and likewise at angles close to 90 degrees. We can apply the same formula to the arrow if we use the angle of the arrow to the plane perpendicular to the flight path, or simply tan(45-angle/2). This would mean that our arrow at 4.2 degrees penetrates looses 7% of its penetration. But this is only true, if the arrow does not tilt further during penetration. If it does tilt, it loses even more penetration. Of course, the arrow's FOC has no effect on how far it tilts in the wind, but during penetration, it does.

The arrow is tilted by a force acting on the broadhead. The lever for tilting it is of course the distance from the broadhead's tip to the center of gravity. At the same time, as with all forces, the heavier the arrow, the less the movement for the same force. With all forces trying to **rotate** an object, the resistance to rotation is defined as the *moment of inertia*. For any object this is the sum of the product of all particle's weight with how far they are from the COG. This for an arrow can be approximated as:

$$I = \frac{W_p \times L_f + W_{gpi} \times L_f \times L_f/2 + W_{gpi} \times L_b \times L_b/2 + 40 \times (L_b - 3)}{7000 \times 12}$$

where L_f is the length of the shaft in front of the COG,

L_b is the length of the shaft to the back of the COG,

and the answer is in foot-pounds (no, this is not comparable to energy).

For a 480gr arrow (125gr broadhead, 30" long, and 10.5gpi) this is 0.054, and for a 610gr arrow (210gr broadhead, 30" long, 12gpi), it changes to 0.069. For a "typical IBO arrow", 125gr point, 30", 350gr total) the value is 0.42. This just means that that you need 0.069/0.042 = 1.6x more force to rotate the 610gr than the 350gr one, or for the same force, it will tilt 60% less. (Note 610/350=1.7, so for all the variability in the target, we may probably skip all the math and

just use relative arrow weight...)

To recap, for tilting an arrow, we can use the length of the shaft in front of the COG as the lever against which the tilting force acts, and the moment of inertia as the resistance to rotation. But there is another factor that needs to be looked at.

The deeper the arrow penetrates the more of the shaft is in contact with the target. This means the tilting increases as the arrow penetrates and the influence of the tilting increases. Another big problem with trying to quantify this effect is that the size of the force that does the tilting, is dependent on the medium shot into. So we sit with an initial tilt caused by wind (a variable independent of arrow design), and the force (a second independent variable), while we are trying to define a model based on only the arrow.

To escape from this dilemma, we must again state the idea behind this exercise, and that is not to predict how deep your next shot will penetrate, but to define an overall or average tendency. Turning these factors into a relative index is therefore acceptable. And the only way in which to calibrate the model is to look at experimental data.

The only guide we have from experimental data, is Ashby's, and it's totally inadequate for this. So we must end this section as a "work in progress". Watch this space ...

3.1.6   Putting it all together

Either one starts by measuring the penetration resistance (R_O) (the easiest but the least precise), or one measures the dimensions of the broadhead, and calculate it using the formula for R_O (more complicated, but a bit more precise).

Then one calculates the depth of penetration using the model as described earlier.

The penetration depth needs to be more than half the width of the animal, and preferably its total width. Animal dimensions tend to follow a simple relationship where in general body width (in inches) is equal to the square root of the weight (in kg). There are of course animals that lies further from this trend, for example warthogs and rhino what are much wider, kudu that is much slimmer, and giraffe that with its height is too slim for its weight.
But you can see the general trend:

Mass (kg)	Body width (inches)
50	7
100	10
250	15
500	22
750	27
1000	32
2000	45

Now if you think the model is complicated, the mathematics actually simplifies to where more than 95% of the model can explained by:

$$\text{Penetration} = \frac{\text{weight x speed}}{700 \times R_O^{0.828}}$$

Remember, we are not really concerned with the width of the channel here, since it was agreed that all broadhead wound channels exceeds the 7.5mm proven to be fatal within 10 seconds.

It is possible to judge the requirements as predicted by these equations for different R_O values, for each class of animal. Bear in mind that particular species differ greatly in body width, and also as the animal ages, this width

changes.

Penetration Graph:
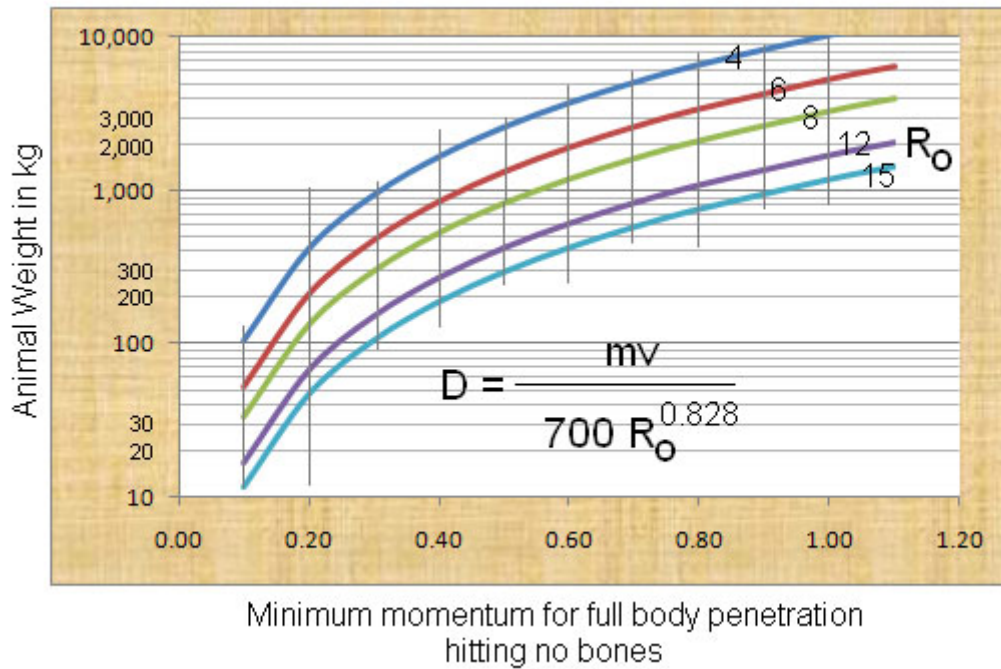
In this graph we have for different resistance values, the approximate momentum required for a full body penetration, not hitting any bones.

However, to add the required kinetic energy to break the rib on entry is not that simple. You cannot simply add momentum to kinetic energy, and you cannot derive the speed needed for each, and add the speeds. The problem with kinetic energy is that the speed it corresponds to, is dependent on the speed itself... a faster arrow will use less speed for the same amount of kinetic energy. So we have to determine the speed the arrow will need for penetration, and then calculate the speed to be added to this, so that the difference in speeds relate to the energy needed to break the bone. Say for a 450gr arrow, you need 150fps for penetration. Now we want to add 20 foot-pounds. For this the arrow has to travel at 141fps. DO NOT ADD THESE!
Instead, add 150^2 and 141^2, and then get the square root, which equals 206fps. However, to add energy needed to break the EXIT rib, you add the speeds without this trick...
The astute observation here is that it takes much more speed difference to break the exit rib than the entry rib...

3.1.7   Required Penetration Depth

Here is a table that implements the WHOLE model...
This is for a kudu bull, at 250kg. Its body width is just under 16" and we speculate it will take 20 foot-pounds to break his ribs. We want a pass through... By the way, the pink shaded areas are where the kinetic energy is less than suggested by the current "Bowhunting Norms and Standards" as defined by the South African government.

"A" is the surface area of the broadhead, and the values inside the table are fps. The first column is to get a pass through without touching a bone. The 2nd column describes hitting a rib on entry, the 3rd hitting one on exit, and the 4th is for hitting both ribs. So you can see that for a 550gr arrow and a 11 lbs broadhead, the predicted range of effective speeds are 187 to 280 fps, corresponding to 42 to 95 foot-pounds.

Do you now realize why shot-placement is the most important factor affecting the

result of a hunt? And here we are not talking about *intended* shot placement (as where you aimed), but *actual* shot placement (as where the arrow struck).

(sq.inch)	(lbs)	Arrow Weight				
A	Ro	450	450	450	450	
1.0	3.0	164	190	202	232	
1.1	4.5	168	194	213	244	sleek 2 bladers
1.1	6.0	173	199	227	258	medium 2 bladers
1.2	8.0	181	208	252	282	large 2 bladers
1.3	9.5	189	217	276	305	small 3 bladers
1.3	11.0	199	229	306	334	
1.4	12.5	213	244	343	n.a.	medium 3 bladers
1.4	14.0	232	263	n.a.	n.a.	small 4 bladers
1.5	15.0	249	280	n.a.	n.a.	3 blade mechanicals/ large 4 bladers

		Arrow Weight				
		550	550	550	550	
1.0	3.0	162	184	191	214	
1.1	4.5	166	187	198	222	sleek 2 bladers
1.1	6.0	170	190	207	231	medium 2 bladers
1.2	8.0	175	196	222	247	large 2 bladers
1.3	9.5	180	202	237	262	small 3 bladers
1.3	11.0	187	209	255	280	
1.4	12.5	195	218	279	302	medium 3 bladers
1.4	14.0	205	230	306	329	small 4 bladers
1.5	15.0	215	240	331	n.a.	3 blade mechanicals/ large 4 bladers

Broadhead cutting resistance Ro

Imagine you were satisfied to hunt with the suggested minimum requirements - 187 fps. The model predicts that if you do hit a rib on entry, you only have 7.1" of penetration left. This will be sufficient to kill the kudu, but only if you shot it perfectly square. If it was 30 degrees quartering away, you would have needed 9.1" penetration to traverse half the body. 7" may result in a loooong walk...

This illustrates the danger of "hunting on the edge". Following minimum recommendations as per category #3, of 550gr at 187 fps, you should achieve 7" with a full quartering shot, breaking one rib on entry. However, at a 45 degree angle, quartering away, ignoring the fact that breaking the rib at this angle takes more energy, you only achieve 77% of the required penetration. Changing the broadhead from a 11 lbs to a 8 lbs broadhead, you can push it back to 100%.

When discussing the particular categories of animals later on, we will draw similar tables for each category, with its recommended arrow weights.

Further Reading: Herman Brand, **AB&A**, Mar 2007, p30, *"Die pyl in pyl en boog"*
Seppie Celliers, **AB&A**, Dec 2007, p56, *"Pyle maak 'n groot verskil"*

3.2   Bow Efficiency

Bow efficiency is the ratio of the arrow's kinetic energy, to the energy used to

pull the bow. To determine the energy used to pull the bow, you need a bow-scale. With this you can draw what's called the draw-force curve. It is basically how hard you need to draw the bow, at each particular point in the draw. So what you do is to measure the draw force for the bow at every inch as you draw it. The sum of all these measurements is the draw energy in inch-pounds, which when divided with 12, gives foot-pounds.

There is a difference in the draw force when you pull the arrow back, and let it down slowly. This is called hysteresis, and can be summed up as friction due to movement and internal friction (resistance to bending). It is always slightly less when you let it down than when you draw the bow. But we are not going to worry about this too much.

Some of the energy stored in the bow is also lost to sound, vibrations and heat. The efficiency of the bow is usually between 60 and 80%.

To measure the arrow's kinetic energy, you need a scale which can weigh in grains, and some way to measure the arrow's speed. A chronograph comes to mind, but there are other ways as well - to be discussed later. For now, we assume you measure the arrow's speed using a chronograph.

The kinetic energy can then be calculated with the arrow's weight and speed: KE = weight x speed^2 / 450240. I assume you measure the arrow's weight in grains, and the arrow's speed in feet per second (fps). This formula gives you a value of between 40 and 110 foot-pounds. The energy needed to pull a bow is usually between 50 and 180 foot-pounds.

However, the exact percentage of the energy that ends up as kinetic energy of the arrow is not a constant value for a particular bow. The efficiency is dependent on the weight of the arrow, and sadly is also not directly proportional to this weight. Therefore the simplest model, as single percentage at "IBO standards" (350 gr shot at 70 pounds draw weight, 30" draw length) is informative, but not conclusive.

A better model is the so called *virtual mass* model. This postulates that the loss of energy can be modeled as an additional imaginative weight that can be added to the arrow. The total energy used to draw the bow, and the arrow's speed and weight, can then with the equation be used to calculate the virtual mass of the bow. This value is independent of the arrow mass, and becomes a better indicator of bow efficiency: Total Energy = (arrow weight + virtual weight) x arrow speed^2/ 450240.

You can of course omit to measure the total energy. The equation then contains two unknowns, which can be solved using two arrows of different weight. But luckily you don't need to do the maths, you can use the tools in the spreadsheet to do this. This model works well over a range of arrow weights, but also has its limits. The virtual model predicts that as you increase the arrow weight, the arrow's kinetic energy will always increase, reaching a limit close to the total draw energy. This is a better fit for traditional bows and recurves, but with compounds there is a definite optimum arrow weight, beyond which its kinetic energy decreases as arrow weight increases. A better energy model for compound bows looks like this:
Draw energy = (arrow weight + virtual mass + K(arrow weight)^3) x arrow speed^2 / 450240

It looks the same as the virtual mass model, but includes an additional factor that starts to suck up energy only for arrows weighting more than about 600gr. Again, you don't need to do the maths - there is a tool with which you can calculate the values for the virtual mass and K, for a particular bow, for three different weighing arrows.
By the way, the virtual mass in this model is **not** comparable to that in the virtual mass model for longbows and recurves...

But, now we have two numbers with which to compare bows with each other. Which is generally a problem for us mere bow-hunters. Just have a look at the mental resistance to drop either KE or momentum as penetration indicator for arrows, in favour for weight and speed (two values). The more values you use, the more accurate your representation of the real bow becomes, but the more difficult it is to comprehend the difference.

We can easily comprehend that a virtual mass of 70gr is better than 90gr, but what would be the best if for **virtual mass** bow A is better then B, but for the value of **K,** B is better? Luckily for the efficiency model, virtual mass is applicable to lighter arrows, and K for heavier ones. So if you want to shoot competitions with light arrows (to achieve a flatter trajectory) small values of virtual mass should be important. If you want to hunt with fairly heavy arrows, 800 to 1000gr, a smaller value for K would be more important. But this answer is still a bit fluffy. Here is a typical graph of how speed, kinetic energy and momentum changes with an increase in arrow weight for a particular bow:
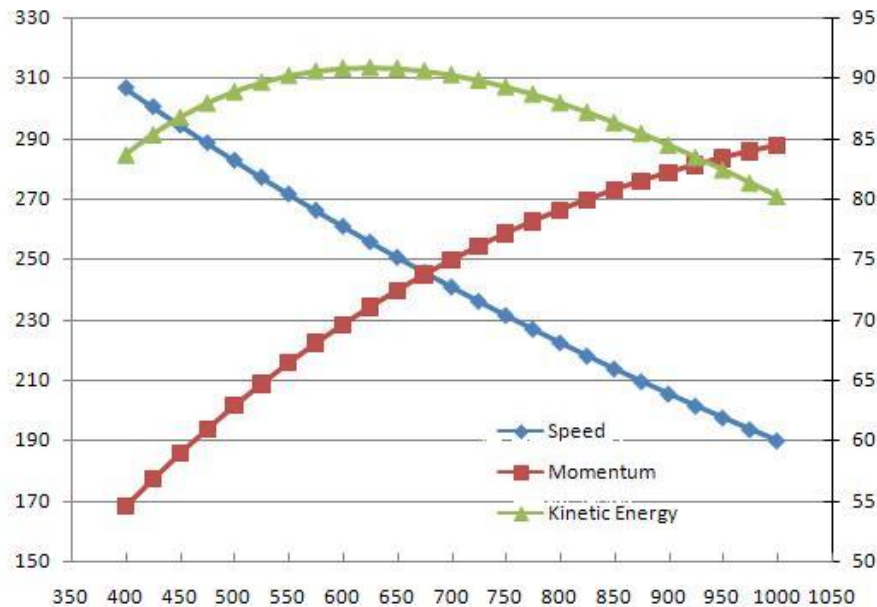
The best way in which to compare bows in relation to efficiency, using this last equation, is to calculate the speed that the bows would shoot the particular arrow you plan to hunt with. The bow which attain the highest speed would of course be the most efficient. By the way, I am assuming these bows are all of the same poundage, and draw length.

Also bear in mind that cam-design will have a influence of efficiency. You may end up calculating that bow A is more efficient than B, but B draws and shoots more accurately than A! And the first principle of bowhunting is accuracy, not penetration!

Further Reading: Harry Marx, **AB&A**, Nov 2008, p30, *"Comparing Bows with bows: virtual mass"*
Herman Brand, **AB&A**, Nov 2006, pi, *"Beste Boog?"*
Dieter Noli, **AB&A**, Nov 2006, p59, *"Bow evaluation methods"*
Rean Steenkamp, **AB&A**, Jun 2006, p43, *"Who says a longbow isn't good enough?"*

3.3   Bleeding and Penetration

There is often a discussion on if serrated or smooth honing of the edge works best. The general experience pulled upon here is that knifes with serrated edges usually cuts meat and sinew easier than smooth blades. Sharp serrated edges are easier to make, and in theory keeps longer than a smooth edge as only the protruding parts blunt against bone. These arguments do not hold water too well for hunting points. A hunting point should be used only once, and sharpened thereafter.
(Oh, and very definitely cleaned and sterilized before you sharpen it, and thereafter. Most often it passed through the animal and landed in the dirt. There are very scary things in dirt, and you can end up with an inconvenient cut, or a very serious infection. Likewise, if you wound an animal, there is a chance that it will heal if you do not find it. If the wound infects, the animal is doomed to a slow and painful death.)

The serrations on such a blade do allow it to cut/tear slightly faster through tough sinews etc., however in the process the amount of cellular damage is more than with smooth blades. It may cut quicker, but the resistance against being cut is so much the greater. It's like when you saw wood - the bigger the teeth on the saw, the more resistance it experiences.

Broadheads should be very sharp to cut with the least possible cellular damage, else more clotting factors are released. Clotting factors will slow down the bleeding, and increase the distance the animal will run before becoming unconscious. This damage also releases a whole enzymatic cascade that causes blood clotting to initiate. Since the idea of the hunting point is to cause the animal to bleed to death, you don't want clotting.

An animal needs to lose about 30% of its blood before it expires. This can be as bleeding "out" - leaving a blood spoor, or internally, leaving no spoor. However if a large artery is severed, this can occur within 10 to 15 seconds. Damage to an artery causes it to contract, or constrict. This slows down the bleeding and can help clotting. The less damage, as with smooth blades, the less this constriction.

As bleeding rate is sometimes likened to the result of the surface area of the cut, it would seem logical to use as many as possible blades. However, it is not flesh that bleeds, but arteries. And no matter how many times you cut an artery, it bleeds just as fast as if it was cut once. So arguments and opinions abound - we will look at the facts.

If you draw a circle with the same diameter as the broadhead's cutting diameter, and in it the cuts made by the broadhead, you can easily see that with 2 bladed broadheads, you can draw many lines representing arteries through the circle that does not get cut. When you do this with a 3 bladed broadhead, the chance of an artery being cut by any blade drastically increases.
Or so it seems - we still have to figure in the penetration depth...

For a four bladed broadhead, the probability of cutting an artery in this circle increases even more. But what also increases drastically now is the probability of cutting the same artery twice. This does not add to the rate of bleeding, but definitely uses up more penetration ability. When increasing the number of blades, this higher friction decreases the depth of penetration.

So although bleeding is proportional to total cutting area, this cutting area, if derived from multiple blades rather than cutting diameter, may not be as effective.
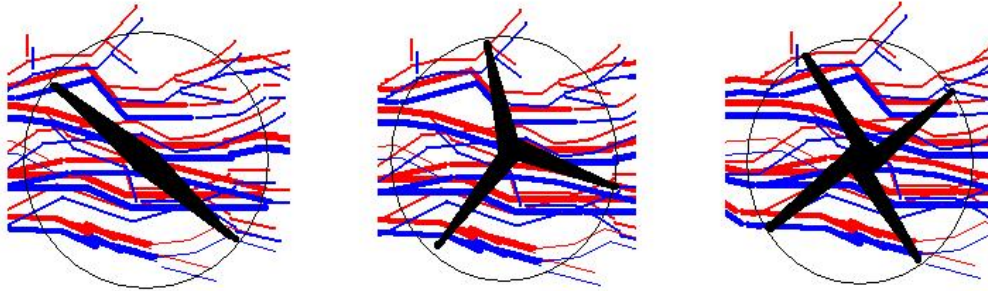
Now if you are interested in mathematical proof, you can read the next paragraph, else you can skip it to a very surprising conclusion...

Assume broadheads with a cutting diameter of 1".
The probability of an artery being cut is equal to the average height (the integration of the height of the top most blade above the arrow on being turned 360 degrees) divided with the total cutting radius. For a two bladed broadhead this *average cutting diameter* (ACD) is about 63%, for three blades 83%, and 4 blades 90%. As you can see there is about a 32% increase going from 2 to 3 blades, and about an 8% increase going from 3 to 4 blades. But don't get excited yet. If we only look at cutting energy, and ignore friction, and use that to predict penetration, and if 2 blades penetrate 20 inches, then three blades will penetrate 20*2/3=13.3" and 4 blades 20*2/4=10". The ACD is however 0.63, 0.83 and 0.90 inches, which means that the average cutting *area* (ACA) is 12.6", 11" and 9". Whow, this ACA actually decreased! Furthermore any surface friction for 4 blades passing through the animal, can only be more than that for 3 blades, which is again more than that for 2 blades. Therefore 4 blades must have a smaller ACA than 3 blades, which have an ACA than 2 blades! Now also add to that the bigger chance of 4 blades cutting arteries twice, and not increasing bleeding, the picture is very dim for 4 blades.

We can now add friction and see its influence as well. We start off with a field point that penetrates 20".
For these calculations we define a new energy unit called ips, which are inches of penetration. This means the field point had 20ips. Then we shoot a 2 blader with a round nosed chisel point, and see it penetrates 15". This is just a fieldpoint with two blades added well back of the tip. This would imply, that since both arrows had the same amount of energy to start off with, that (20-15)/20 = 25% of the energy, 5ips, now went into the cutting, leaving 75% for penetration, 15 ips.
It means that each cutting blade used 12.5%, or 2.5 ips, to cut 15" deep, and the arrow used 15 ips to penetrate 15".
We can write an equation for this:
    D x 2.5/15 + D x 2.5/15 + D x 15/15 = 20", where D is the depth of penetration, which is 15".

If we add a third blade, that 3rd blade will also use 2.5ips to cut 15" deep, but we don't know how deep it will go now. That is what we want to calculate:
    D x 2.5/15 + D x 2.5/15 + D x 2.5/15 + D x 15/15 = 20, and now D is 13.3".

For 4 blades the penetration depth would be:
    4 x [D x 2.5/15] + D x 15/15 = 20, 12".

The ACA's are now 9.45sq", 11sq", and 10.8sq". Now the 3 blader is the most lethal.

The general equation would be

```
        D = D_0 / [B (D_0-D_2)/2D_2 + 1], where D_0 is the field point
    penetration, and D_2 is the 2 blader's.

    With this we can investigate a whole spectrum of possibilities:
        D_0   20"
        D_2   (penetration)        ACA (average cutting area)
        inches                        square inches
        2x      3x      4x        2x      3x      4x
        10      8.0     6.7       6.3     6.6     6.0
        11      9.0     7.6       6.9     7.5     6.8
        12      10.0    8.6       7.6     8.3     7.7
        13      11.1    9.6       8.2     9.2     8.7
        14      12.2    10.8      8.8     10.1    9.7
        15      13.3    12.0      9.5     11.1    10.8
        16      14.5    13.3      10.1    12.1    12.0
        17      15.8    14.8      10.7    13.1    13.3
        18      17.1    16.4      11.3    14.2    14.7
        19      18.5    18.1      12.0    15.4    16.3

    In this table we can see that for example in row 3, if a field point
    penetrates 20", and a 2 blader 12", then a  3  blader  will  penetrate
    10", and 4x only 8.6". Their cutting areas will be 7.6sq", 8.3sq", and
    7.7sq".
    From this we can also see that only if the 2 blader penetrated to
    deeper than 80% of the field point, does it make  sense  to  use  a  4
    blader. At all other set-ups, a 3 blader causes the most bleeding.
```

Which emphatically proves that 3 bladed broadheads are better than 2 or 4 bladed ones where lethality is concerned, unless penetration is needed, for which 2 bladers are better, and unless you get pass through's, in which case 4 bladers are better.

If you do get pass-through's, the best broadhead is always the one that cuts the largest cutting surface (blade count x cutting diameter), and just falls out of the animal at the other side. If you frequently get pass-through's, you can consider going bigger with the broadhead.

```
Which is basically common sense isn't it?
```

Now before we step of this topic, there is another interesting opinion about bleeding to take note of. Internal bleeding is good, but external bleeding even better - it leaves a nice trail to follow. If you cut a straight cut through hide, and stretch it, you will notice that you can actually "pinch" it close if you pull in the direction of the cut. Three and four bladed broadheads cut a pattern that cannot pinch close. Therefore some 2 bladers have an extra 2 small blades. These are called bleeder blades, and their sole purpose is to ensure that you still have the penetration of 2 blades, while the cut cannot be pulled close.

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Further Reading: Herman Brand,  AB&A,  May 2007,  p32,  "Minder Bloed"
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3.4   Shooting Distances

3.4.1   ...based on Reaction Time

In the past speed was one of the most important factors of a bow as promoted by industry. This of course makes sense if you are selling bows. The IBO standard (being misused as it is) set a constant arrow weight, and allows the buyer to make a rudimentary/superficial comparison between bows. More importantly, it allowed manufactures to advertise "mine's bigger than yours". The standard could have been defined differently - what is the heaviest arrow the bow will shoot at 200 fps? This (although totally impractical) would have instead led to a weight race...

So everybody (and in USA still) came to believe speed was most important. It helped of course that kinetic energy is more dependent on speed than weight, as opposed to momentum. This tendency we think, has however been reversed in South Africa. Dr. Ashby and others has shown that momentum plays a bigger role in penetration into flesh. This led to the extreme emphasis shifting from speed to arrow weight as the all important factor, encouraged by among others the author.

As we fight against using extreme speed to compensate for low arrow weight, we fight against the use of extreme arrow weight to compensate for low speed. This tendency has long since been seen in the traditional-bow environment, where extreme heavy arrows were used to get enough penetration despite low speeds. But it comes at a price. This price is the theme of this chapter.

It is often asked what the minimum speed of a hunting arrow should be. There are two principles you can follow to answer this, and speed's contribution to penetration is discussed elsewhere. Instead, these two factors are accuracy, and reaction time. We will first look at accuracy, then reaction time, and then go some way to define a sensible balance between speed and weight.

The issue about accuracy is as follows - even if you ranged the animal with a rangefinder, it may step closer or further just one or two steps, and change the impact point. This is exactly the same as using for example the 40Y pin for an animal ranged at 39Y. But the influence can't be by much, we hear you protest.

```
Shooting high (+) and low(-), for animals at various distances, for  different
arrow speeds, that comes closer 1Y after ranging,  for  elevations  relative  to
anchor point +1 to -5Y.
     50Y          40Y          30Y          20Y          10Y
150 4.0 to 3.1   3.4 to 2.9   2.6 to 1.9   1.8 to 0.9   1.1 to 0.0
175 3.1 to 2.7   2.5 to 2.0   1.9 to 1.3   1.4 to 0.4   0.9 to -0.3
200 2.4 to 2.0   1.9 to 1.4   1.5 to 0.8   1.1 to 0.2   0.8 to -0.4
225 1.9 to 1.5   1.6 to 1.0   1.2 to 0.5   0.9 to 0.0   0.7 to -0.5
250 1.6 to 1.1   1.3 to 0.8   1.0 to 0.3   0.8 to -0.2   0.6 to -0.6
275 1.3 to 0.9   1.1 to 0.6   0.9 to 0.2   0.7 to -0.3   0.6 to -0.7
300 1.1 to 0.7   0.9 to 0.4   0.7 to 0.1   0.6 to -0.4   0.6 to -0.7
```

In this table we can see the error caused by the ranged animal stepping closer to you, by a mere 1Y. This error was calculated using a parabolic trajectory, and therefore assumes no speed loss (speed loss increases the error slightly more). The values are all in inches.

This table shows us that for example shooting with a 200fps arrow: you will shoot just more than 2" high if the animal moves from 50Y to 49Y. What it also shows is if you want to half this error, you need to increase the arrow

speed to at least 250fps, or decrease your hunting distances to 30Y.
Also, a very interesting phenomenon is that when shooting from a tree hide (5Y high), at 250fps instead of shooting high at 20Y, you shoot slightly low! This is seen for 10Y for all the speeds. It of course has to do with the form of the trajectory, and that 1Y is a bigger percentage of 10 than 50. On average, the error always decreases with an increase of speed.
So on face value, it is very intuitive to claim that higher speeds are the solution to ranging problems, but shooting at closer distances can decrease the error too. If you are having problems with vertical accuracy, speed will decrease the error, but accurate ranging will eliminate it.

Figure 1a:
Here we see how travel distance changes with animal comming closer 1Y: So - Sr.

Figure 1b:
Here we see the intended impact point being missed.
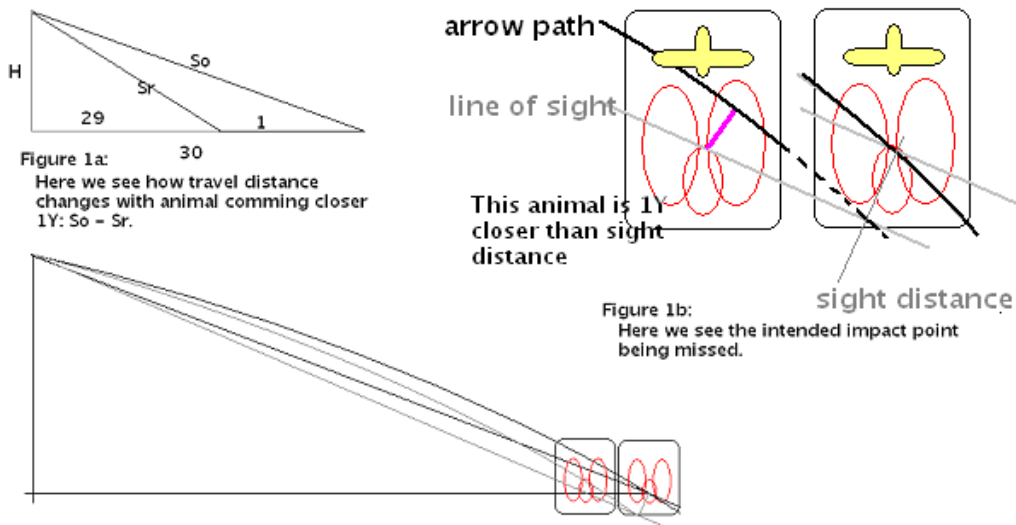
If you take a video recording of an animal being shot with a standard video camera, the frames or still photos it takes, is about 25 per second. This means the frames are 0.04 seconds (40 milliseconds) apart from each other.
You can therefore, based on in which frame they react, determine the time it took for them to start jumping. If you look at the "Impact" video by DP Bierman and Redge Grant, they reflect on a number of experiments doing exactly this.
What they found was that very alert impala can react within 2 frames of the shot being fired (80ms). At the same time, a very relaxed animal, surrounded by other animals and guinea fowl, did not react even on frame 5 when the arrow hit.

This implies reaction times that can start at just below 0.1 seconds (100 milliseconds), but can also be as slow as 200 milliseconds.

If you shoot at an impala at 20Y, with an arrow at 250 fps, the animal has 187 milliseconds to react between the sound reaching it, and the arrow doing so. If you wish to reach the animal before 100 milliseconds, you will have to shoot at 395fps.

Moral of this story - if you want to decrease the probability of the animal jumping, by increasing arrow speed, you will only be partially successful. There are a few other ways of also decreasing "string jump", for example shooting heavier arrows that decreases energy loss and lowers sound frequencies and amplitude, or putting on sound dampeners, or standing a bit deeper in the hide, waiting for the animals to calm down, etc...

Here we see the time (milliseconds) between the sound and arrow reaching the target, the distance the animal can "fall" during string jumping (reacting only

after 100ms), and the speed at which it would be falling by this time. Clearly you can see the need for 275+ fps at 30Y and 200+ fps at 20Y, to minimize string jumping.

	Time (milliseconds)					Distance (inches)					Speed (fps)				
	50	40	30	20	10	50	40	30	20	10	50	40	30	20	10
150	868	694	521	347	174	114	68	34	12	1	25	19	14	8	3
175	725	580	435	290	145	75	44	22	7	0	20	15	11	6	2
200	618	494	371	247	124	52	30	14	4	0	18	13	7	5	1
225	535	428	321	214	107	37	21	9	3	0	14	10	7	4	0
250	468	374	281	187	94	26	15	6	2	0	12	9	6	3	0
275	413	331	248	165	83	19	10	4	1	0	10	7	5	2	0
300	368	294	221	147	74	14	7	3	0	0	9	6	4	3	0

What is even more effective, as proven in this video, to decrease string jumping, is to wait for the animal to relax or shooting only when they are calm. Birds and other animals causing some natural noise are also very beneficial.

Therefore, we could conclude that speed does flatten the trajectory slightly, and does decrease the probability and extend of string jumping, but never believe that speed will solve these problems. Instead, a concerted approach, where also other techniques and factors are used, is most successful.

Shooting at shorter distances always decreases your grouping size. This alone should be a big reason to do so. It also decreases reaction time for the animal drastically. From these tables you can see the linear relationship between distance and reaction time. Going from 40 to 20 yards (very do-able), to get the same decrease using speed, you will have to double the arrows speed (almost impossible).

Another ground for differentiating between for example a spear and an arrow, is the speed of the projectile. The influence of the speed of the projectile on accuracy will be discussed in the following paragraphs. Its influence on penetration is however also critical for a totally different reason than momentum. It ties in with FOC as discussed above.

A faster projectile gives the animal a shorter time to react to the sound of the projectile (or for any other reason).

The importance of a moving target on the penetration of a slow projectile is easily imagined as the moving animal will cause the projectile to slant during impact. This will decrease penetration in exactly the same way as an imperfect trajectory due to a too low FOC. Again, we will only capture this effect as a general guideline, since currently it does not seem sensible to try and quantify it other than as arrow speed.

When discussing reaction time, the debate is usually centered on two opposing facts: (a) the further you are from the target, the more time the animal has to react, and (b) the further you are, the less noise reaches the animal. (Another factor that also affects the noise that reaches the animal is the density of the bush, vs. over water). **Accuracy decrease proportional to distance, time to react increases proportion, but the level of sound decreases by the square of the distance.** At each distance, you make the call and take the risk.

Traditional archers have for many years proven that slow, heavy arrows are also very effective hunting projectiles. We have also seen very low poundage bows used by children, and medium power bows by women, to hunt very successfully. Indeed it would be a sad day if proposed recommendations exclude traditional bows, children and women from bow-hunting. What we have discussed so far in fact

does make provision for these hunters. The first factor described as essential to bow hunting is accuracy.

Accuracy is increased for all hunters by merely shooting at shorter distances. The reason for suggested optimum mass and speed being high in general is to compensate for a slightly less than perfectly placed shot. In realizing the constraints these hunters function in, we can see that by reducing the maximum suggested range, we in turn reduce the probability of the animal moving, increase the target size, and therefore increase the probability of perfect shot placement. In combination with shorter hunting distances, the use of 2 bladed hunting points with minimum cutting diameters ensures achieving needed PA.

In turn, defining suggested maximum ranges for all categories of bowhunters is also of ethical importance. This ties in perfectly with accuracy as discussed above. The temptation is all too great for trying to suggest a measurement of an archer's accuracy, and therewith provide suggested maximum hunting distances. The reality is however that even if a hunter could accurately hit the target animal's vitals at 80Y, the time for the arrow to reach the animal will be relatively long, and thereby its movement during this time ("string jump") will negate all the care that went into the perfect shot placement. It is generally accepted by bowhunters that about 20Y is the maximum range for Category #1 animals (and definitely for warthogs as well) at arrow speeds of about 250fps. Larger animals are generally slower to move, and 30Y is quite acceptable for the large antelopes. For Giraffe and buffalo, 40Y is not unrealistic. The maximum suggested hunting distance is not a function of the hunter's accuracy, but indeed of the animal's reaction time (and size of vital organs) vs. the speed of the arrow.

At the generally accepted arrow velocity of 250fps, animals at 20Y have about 0.2 seconds to react to the sound and animals at 40Y about 0.4 seconds.

If the arrow mass is 800gr, arrow speed is 188fps, and Ro is 8 lbs, the penetration is around 40 inches. According to the optimum recommendations on mass and velocity, this would qualify as a perfectly acceptable hunting arrow for all categories. In reality this velocity would provide the animals 0.280 and 0.580 seconds at 20 and 40 yards to react. This is in regards to reaction time, as (un)acceptable as shooting a 250fps arrow at an animal at 60+ Y. Therefore, the suggested decrease in maximum hunting range of arrows that does meet the optimum speed recommendation with the adjusted speed, but in reality is slower, is suggested in line with a reaction time of 0.2 to 0.4 seconds.

Another factor plays a role in defining maximum distances. Arrows loose speed due to friction in air, roughly at about 1% per 10Y. An arrow at release may have 40 ft.lbs energy but at 60Y it may only have 35 ft.lbs (for 570gr at 195fps). Arrows shot to an elevated target looses speed more quickly in relation to the angle. Arrows shot to a downhill target looses speed much slower again. However, when staying within the recommended speeds, this effect is overshadowed by accuracy and reaction time compensations.

```
Proposed Maximum Yardage based on Reaction Time
 Category              #1      #2      #3      #4+
 Reaction Time
 (seconds)    0.15    0.2    0.25    0.3     0.4
 Arrow Speed   Recommended Maximum Distance (yards)
     150         9      12      15      17      23
     175        10      14      17      21      28
     200        12      16      20      25      33
     225        14      19      24      28      38
     250        16      22      27      33      43
```

```
275        18      25      31      37      49
300        21      28      35      41      55
```

Based on the assumption that the animal is calm, using the formula:
Distance = Time x arrow speed x speed of sound / (speed of sound – arrow speed)
If the animal is nervous, use the lower category's time.

3.4.2   ...based on Grouping size

"Effective range is the ability to place 80% of your arrows in an 8"circle (20 cm)." - Cleve Cheney.

The above rule, which is quite sensible, is a very general guide, and does not make provision for the massive differences in sizes of African animals. This writing allows for a range of 4" to 8" circles, for various categories of animals. The term *maximum* range is to a degree more rigid than *effective* or *optimum*, however we would like to stress the importance of this concept to the hunter. It is something which should not be compromised upon.

The Vitals' Area Diameter (VAD) is defined as the diameter of the largest circle that fits inside the shot window to the vital organs (heart and lungs) that miss all the major bones.

The proposed maximum yardage based on accuracy is done in relation to the basic unit of a grouping size – its diameter. A grouping with circumference of 10" (measured as suggested later on), has a diameter of 3.3", and when shot at 50Y, an angle of 0.066"/Y. It implies on for example category #1 animals a shot at the furthest of 4"/0.066Y, which is 60Y. Building a safety factor into it with double the grouping size this distance becomes 30Y. Here is a table with some values:

```
Category                #1  #2  #3  #4  #5  #6
Average vital dia       4"   5"   6"   6"   7"   8"
Circumference   "/Y    Recommended Max Distance* (Y)
     24"     0.160    13   16   19   19   22   25`
```

```
 22"     0.147    14   17   20   20   24   27
 20"     0.133    15   19   23   23   26   30
 18"     0.120    17   21   25   25   29   33
 16"     0.107    19   23   28   28   33   38
 14"     0.093    21   27   32   32   38   43
 12"     0.080    25   31   38   38   44   50
 10"     0.066    30   38   45   45   53** 60
  8"     0.053    38   47   56   56   66   75
```
 * safety factor=2
 ** shots at 50Y and beyond are generally not recommended.

The proposed method for measuring group size is to measure the circumference of
the smallest polygon that covers 6 shots, i.e. shoot 6 shots and wrap a tape
measure around the shafts where they enter the butt. This value is then divided
with 3 (the mathematical constant PI is about 3) to approximate diameter, and
then with the distance tested at. For ex. 20" circumference at 50Y is
20/3/50"/Y, which gives a grouping of 0.133"/Y.
In order to calculate the distance proposed, use:
    Vital Diameter / Grouping size / Safety Factor.
This safety factor is a matter of personal choice, and 1 to 2 is suggested. The
above table uses 2, which allows for an error that's double the hunter's
grouping size, and is considered very safe. A value of 1 leaves no margin for
error.

3.4.3   Measuring the correct hunting distance

Here is a simple procedure to measure your hunting distance quickly.
Draw a picture, life size, of the kill zone for the animal you want to shoot.
Then draw the largest circle that fits into the kill zone.
Now stand at about a distance you would expect to shoot half the arrows
inside the circle. Let us say this is 35Y.
Now shoot 35 arrows at it, as many as how far you are in yards from it.
Now count how many arrows are inside the kill zone.
The number of arrows inside the circle, is the maximum distance you should
be hunting this animal at!

Further Reading: Cleve Cheney, **AB**, Mar/Apr 2001, p13, *"Optimum
Range – knowing when to shoot"*
Cleve Cheney, **AB&A**, Jan 2008, p30, *"Long shots – why not?"*
Cleve Cheney & Jan Burger, **AB&A**, Jan 2007, p39, *"Close shooting
makes good sense"*
Engee Potgieter, **AB&A**, Jul 2007, p52, *"Rooibok – die
snaarspringkoning"*
Engee Potgieter, **AB&A**, Apr 2007, p25, *"Bowhunting Bread and Butter"*

3.5   Equipment

3.5.1   Traditional Bows

Further Reading: Johan Smit, **AB&A**, Sep 2006, p51, *"Traditional bows –
stronger than you may believe"*
Johan Smit, **AB&A**, Nov 2006, pi, *"Watter Traditionele toerusting is
reg vir my?"*
Johan Smit, **AB&A**, Jun 2006, pi, *"Sorg vir jou Tradisionele Boog"*
Johan Smit, **AB&A**, Mar 2007, p29, *"Tradisionele boog en die spoedmite"*
Johnny Snyman, **AB**, Nov/Dec 2000, p28, *"Making a Flemish Splice
Bowstring"*

Johnny Snyman, **AB**, Jan/Feb 2001, p14, *"Making a Flemish Splice Bowstring - Part 2"*

3.5.2 Compound bows

Upper Limb

Limb Bolt

Riser

Grip

Stabilizer Insert

Limb Pocket

Lower Limb

Axle

Split String

Shooting String

Barrel Nut
Quiver Mounts

Cable Guard

Lock Mount
Rest Mounting
System

Cam
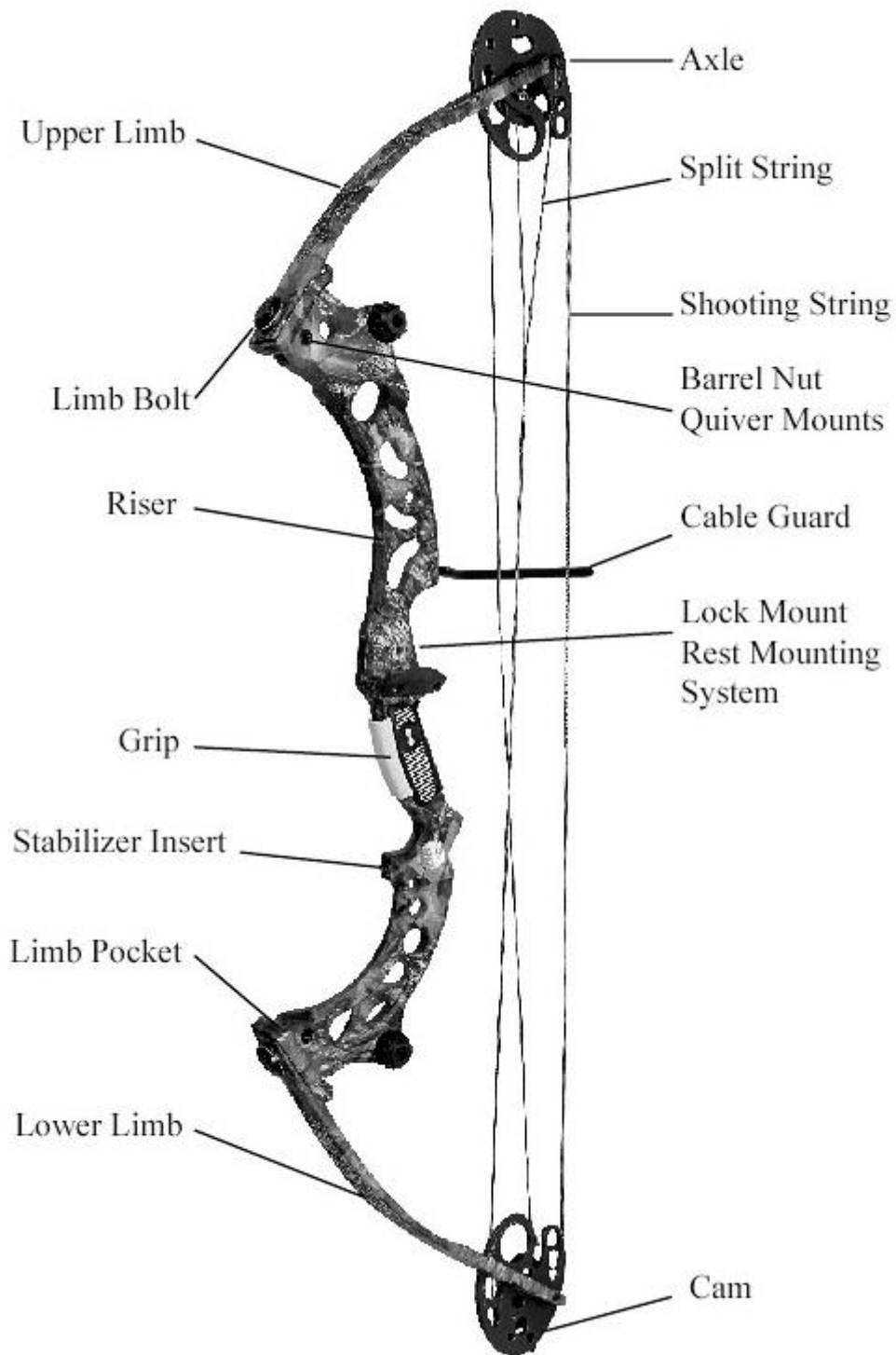
Further Reading: Seppie Celliers, **AB&A**, Oct 2007, p51, *"Hoe kies ek 'n boog wat my pas?"*
Herman Brand, **AB&A**, Nov 2007, p52, *"Feite en Opinies"*

3.5.3 Arrow Rests

The very first arrow rest, still in use, is the shelf, or riser of the bow, and against the hand. This works perfectly if your arrows are tuned for the type of rest. The arrow vibrates during release at a particular frequency. When the arrow is released, the string pushes it against the riser, and bends it. This bend initiates a vibration that takes the flights of the arrow out of the way of the riser. Of course, if the arrow vibrates at the wrong frequency, the flights do not clear, and makes contact with the rest. This can cause inconsistent groupings. This is the very reason traditional archers uses feathers for fletching. Feathers are also less rough on the hand.

The next step in the evolution of the rest involved a fixed shelf and "button". Like the riser itself, these do not give way when the arrow pushes against it. The same tuning of the arrow is needed to get the flights to clear.

Popular on recurves are spring rests and "plunder buttons". These support the arrow during aiming, but can be pushed away by the arrow as it bends. An aspect not frequently discussed is the damping of vibrations in the arrow by the touch of the rest.

Also very popular, more so on compound bows, is two prongs. The flights of the arrow, or the nock, must be fixed such that one flight passes between these prongs. They are usually also micro-adjustable for center-shot (adjusting the rest left or right), to minimize fishtailing. The height of the rest in turns control "porpoising", or the arrow moving up and down.

Do take note that all arrows shot from traditional bows will fishtail. Arrows shot from compounds, especially those with single cams, tend to porpoise or vibrate vertical. This is of course due to the nock travel of these bows not being straight. Read more on this under Dynamic Spine.

All these rests have one undesirable feature, if you nock the arrow and try to stalk with it, it tends to fall of the rest. Also with compounds, if the cams have a "hard wall", the arrow tends to bounce off the rest if you draw too fast into this wall. One rest design in particular is well suited to eliminate this problem, the wisker bisket. These have numerous strong fibers on which the arrow rests, and which hold it "locked" on the rest. Some archers are convinced wisker biskets are not as accurate as prong or spring rests, but then for hunting, your shooting distance is fairly close. On the other hand, I have seen film footage of shooting at 160Y with them, more accurate than I can with my drop-away rest.

All of these rests have two objections to them raised by some archers. The arrow's fletches can make contact with the rest, and any movement of the bow hand is transferred to the arrow during the whole release. I also fell for these, and as such is using a drop-away rest. These rests hold the arrow up, but during release, drops totally out of the way of the fletches. They also exert no push against the arrow as it bends during release. Lastly they also only transfer bow movement to the arrow for the first part of the release. However, they don't contribute to damping vibrations - think of a tuning fork being stuck, and touched, which immediately dampens high frequencies.
Drop away rests are mechanical devices, which as such needs cleaning and care, and is not as robust as prongs.

More as a curiosity, there is also a magnetic rest. The arrow drifts in a magnetic field, and experiences no friction during any part of the release. I have never seen this in action, and is worried that the precise position of the arrow tip will be affected by how it was nocked (think string torque). Also, if you shoot uphill or downhill, the point will not drift at the same height.

3.5.4   Hunting Points (Broadhead) design

Here's just a small sample of broadheads and variety
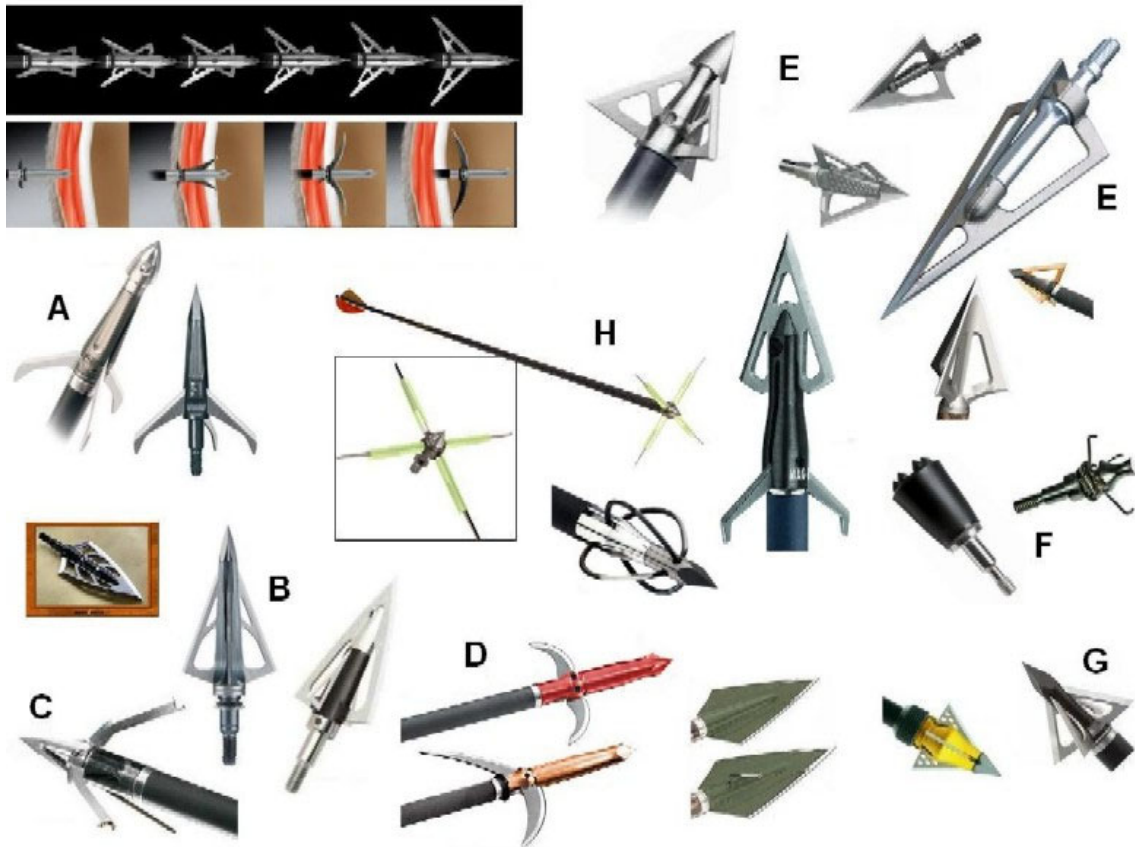
A – Standard mechanicals, opening backwards,
B – Two bladed broadheads with smaller "bleeder" blades,
C – Newer type of mechanical, blades opening forward on impact,
D – Mechanicals opening only once inside target,
E – Three bladed broadheads with short to long blade lengths,
F – Judo and Blunt, for use on birds, rodents etc.,
G – Four bladed broadheads,
Also shown is the sliding action of broadhead opening with blades sliding
backwards, and only opening once inside the target.

3.5.4.1   Mechanical Points

There are currently 4 types of mechanicals, those that open backwards upon
penetrating the skin, those that open by sliding the blades backwards upon skin
penetration, opening forwards on contact, and those that open backwards but only
after penetrating the full depth of the hunting point's length.
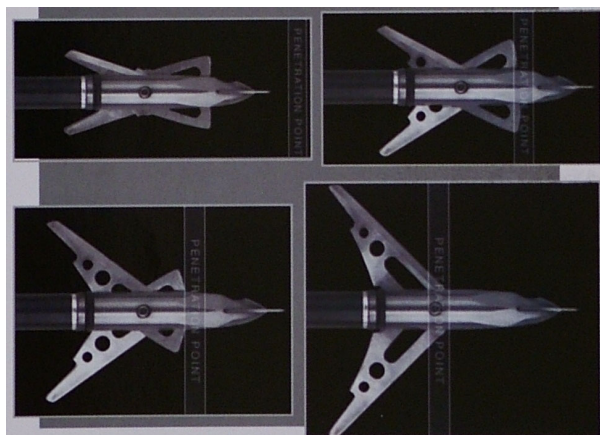
The first type is the more generally used design, opening backwards. It
sometimes causes a small entry wound. It can also be deflected by the opening

45

blades pushing the point away.

This can happen in very oblique shots. The second and third designs with sliding blades promise to open fully before penetration starts, and that no deflection can occur. All three of these types suffer from less robust blade design, and can break upon hitting heavy bone structure. Such breakage of course severely hampers penetration.

The fourth type of mechanical hunting point tries to solve this breakage problem by only opening once it has penetrated a substantial depth, the idea is to open only once inside the rib-cage, and so avoid blade damage during entry. This in turn however may reduce the bleeding rate, increasing the time needed for the animal to go down, and possibly decreasing the blood trail due to the small entry wound. The big advantage of mechanical hunting points is the ease with which to tune the bow for them, once field point tuning was done.

In relation to mechanical hunting points we recommend that only category #1 and #2 animals be hunted. This is however based on the opinion that mechanicals are generally of a less robust design than fixed hunting points. Another factor to keep in mind with mechanicals is that in general the blade angle is larger than with fixed blade points, increasing the resistance to penetration. The big advantage of mechanical hunting points is the ease with which to tune the bow for them, once field point tuning was done.

3.5.5 Bow Sights and peeps

If you are a traditional shooter, you can skip this section. I won't mind. If you are not, a sight is a useful appendage. There are two major designs, a multi-pin and a single-pin sight. Multi-pin sights are most popular, and has a major advantage. The animal you are hunting will move closer and further, and you will have to change the distance you aim at. With a multi-pin sight you need not adjust any setting, and just shoot on another pin. The drawback it has, is that if you are using really heavy arrows, the trajectory is rather pronounced, and you want to aim at very close to the correct height. If you have set your pins on 10 to 50Y, with 10Y intervals, you will have problems at other distances. My advice to set the pins at 20,25,30,35 and 40Y. You should not hunt at further distances anyway, and closer than 20Y the arrow is traveling fairly straight. I shoot with a single pin sight. The reason is purely personal, I like to aim on the pin, and if the animal is it 37Y, I can set it and shoot. I do not need to aim between pins, something which I'm not very good at.

If you use a single pin for hunting, I have one suggestion - don't fasten the screw that locks it onto a single distance. That way you can easily adjust it to any distance quickly. Mutli-pin sights does have an advantage in that you can apply two tricks of the bowhunting trade. One involves shooting through obstacles, knowing exactly the trajectory of the arrow. Read the part on "Shooting through gaps".

The other trick is using it to adjust the distance aimed at, when the animal is at an acute angle. Again, we cover that in the section titled "Shooting uphill and downhill." About the size of the pins, if you are shooting at targets at longer distances, smaller pins is good. If you are hunting, mostly at below 40Y, the pins must be visible, and larger ones might work better. Most shops will swap these without much trouble.

You can also spray them with fluorescent paint. A sight light is useful for shooting in low light conditions. Definitely, we are advising you do not shoot late in the evening, unless you have good dogs and lights for the follow up. However, as bowhunters we frequently hide in shades, and shoot at dark coloured animals.

A light coloured pin can be more visible. On my own site I once added orange fluorescent paint, a dash of white paint, and kept a part of the pin black. I

also replaced the pin with a crosshair... which worked good for me. The best
solution for me is to shoot with a sight-ring, instead of a pin. You center the
intended impact point in the ring, and shoot. Moral of the story... don't get
stuck on pins if you are having accuracy problems...

A frequent problem with sights is that you may have two different arrows, and
the pins or markings are different for them. With some multi pin sights the pins
are fastened on a removable pin rack. These sights come with spare pins and
racks, which makes switching between different arrows easier. The second part of
the sight is of course the peep. This is the little hole in your bow's string,
kept together with a small metallic ring. I bet you never thought you need a
metallic ring to keep a hole together? The peep's major job is to help you
anchor correctly, and aim more accurately. It helps you align the bow in exactly
the same manner each time.

But peeps have one nasty habit, they tend to rotate with the bowstring. Never do
the "final" fit of a peep on a new string. Give it a few hundred shots first.
Once it settles, you can fix the peep. The exact height of the peep in the
string is also tightly coupled with your anchor point. But there is also one
other little known fact about a peep. One of the questions new hunters often
asks is should I focus on the target, or the pin? My eyes are not what they used
to be, and focusing on either is not a solution for me. However, in general, it
is a matter of personal choice. I would suggest you start by focusing on the
target. However, there is another solution. Peeps come in different sizes. The
largest allows the most light through and allows for easy sighting in low light
conditions. The smallest allows the least light through, and can make shooting
in low light difficult. However, like the pin-hole in a pin hole camera, it
focuses everything at all distances. This results in both the pin and target to
be in focus at the same time! If you now also shoot with both eyes open, the
other eye can still help you in low light.

3.5.6   Broadhead Construction

As a rough estimate, cheap broadheads are not as precisely made as more
expensive ones, and the more precisely it's made, the better its aerodynamic
properties. Any skew or bent blades will affect the flight path of the arrow,
and the effect will increase with increased arrow speed.

The centre of gravity of the broadhead is usually slightly further forward than
a field point. This may not have a big influence on FOC and arrow flight, but it
may have a big influence on launching the arrow.
For instance if you use arrows that is 1" longer than what you generally use, it
is expected that the arrow will leave the bow with its nose slightly lower. This
is especially the case if you use a drop-away-rest. The same effect could occur
if the broadhead moves the centre of gravity forwards.

You should also spin the arrow on the broadhead tip, to see if there
is any wobble in the shaft. Sometimes the insert is not 100% centre, or the
tip of the broadhead is not. This will show as a wobble of the shaft when you
spin the arrow on its tip. An arrow with a wobble will not fly straight, as this
off centre tip will create unbalanced aerodynamic forces on it.

3.5.7   Durability

Durability is one of those strange characteristics that are very easy and very
difficult to describe. The easy part says it should not break. The difficult one
is saying when will it break. In general, most fixed blade broadheads are more
robust than mechanical broadheads.
Also cut-on-contact tips are usually less durable that chisel-nose tips.

The thickness of the blades is one indication. The thicker, the better. Of

course, the thicker the more penetration friction, and the more work to keep them sharp.

The material the blade is made from is usually carbon-steel or stainless-steel. These days you also get titanium ones. However, not all steel are alike, even if it is called "stainless" or "carbon". Not only the chemical composition is different, but also the heat treatments it received is different. If the metal is hard, it sharpens well and keeps the edge well, but breaks easy. If it is tough, it doesn't keep the edge so well. One important factor about the steel, if it is too soft, is the edges may not only go blunt easily, but they may even curl around on hitting a rib on entry. This does not only hinders penetration, but also severely diminishes the damage it does. Lung tissue is extremely elastic, and will simply stretch over such a curled edge. This turns your broadhead into a fieldpoint as far as lung tissue is concerned.

Then there are the screws that hold everything together. The thread sizes and materials these screws are made of. etc.

So instead you could determine the quality of the broadhead by actually breaking it. You can shoot it through plywood, animal shoulder bones, metal drums, etc.

Further Reading: Sampie Stoffberg, **AB&A**, Dec 2008, p61, *"Die keuse van 'n jagpunt"*
Engee Potgieter, **AB&A**, Jul 2008, p15, *"What do you expect from a broadhead?"*
Herman Brand, **AB&A**, Jul 2008, p61, *"Jagpunte ... en jagpunte"*
Herman Brand, **AB&A**, Sep 2006, p vii, *"Hoe maak mens 'n jaglem bangskerp?"*
Johan Smit, **AB&A**, Aug 2006, p ii, *"Watter jagpunt is die beste een vir tradisionele boogjag?"*
Herman Brand, **AB&A**, Aug 2006, p iv, *"Hoe skerp is skerp?"*
Fritz Rabe, **AB&A**, Apr 2006, p25, *"Hunting the heavies"*
Dave Holt, **AB**, Jan/Feb 2001, p7, *"Testing broadhead accuracy"*

3.5.8   Arrow stability

There are various factors influencing arrow stability, or how long it takes for an arrow to stabilize after release. In general, longer arrows stabilize quicker, heavier ones slower. But spine, and its center of gravity play major roles. By the way, we assume you have tuned the bow for center shot and straight nock travel.

3.5.8.1   Static Spine and Dynamic Spine

The first major factor that plays a role in arrow stability is its spine. An arrow's spine is how stiff it is. (Actually when measuring spine, you measure how limb it is, but "limpness" never had a chance catching on in the archery community.) An arrow with 280 spine is very stiff, while one with a 500 spine is very limb.

What is true about all arrows is that they bend upon being released. In fact, if you put a static force on the back of the arrow, you'll see the arrow totally collapse at about 20 to 30lbs. Yet, they don't, even when shot in 100lbs bows. The fact is that they actually do collapse, but since they are so quickly out of the bow, they don't get time to bend all the way and break.

There are two types of spine, static and dynamic. Static spine is something you talk about in the bow shop. Dynamic spine is the only thing that controls arrow flight. In fact, dynamic spine is very different from

static spine in that it describes how something changes in time, and many factors that influence it have no influence on static spine.

For all traditional bows, and most recurve bows, spine plays an immense roll in getting the fletching past the riser, without it touching the riser. The arrow's stiffness is precisely matched with the bow's poundage, in order for the first harmonic of oscillations to carry the fletching clear of the riser, as the arrow bends. You can imagine this as if the arrow slithers like a snake around the riser.

For bows with "cut-out" risers, i.e. the riser has a gate for the arrow, allowing the arrow rest to be in the exact forward centre of the string's path, spine plays a different role. The travelling path of the nock from release to the arrow actually leaving the string is not always straight. Therefore the flexibility of the arrow absorbs this uneven travel causing the arrow to vibrate in the same way as it did for straight risers, except that the vibration is now mostly vertical, where previously it was horizontal. The more straight the nock travel, the more tolerant the bow will be for too stiff arrows.

In any case, if the arrow is too stiff, for traditional bows you won't get flight clearance, and for cut-out risers you'll get the point of the arrow being pushed up or down. If the arrow is too limb it simply bends too much, and the broadhead will steer the arrow all over the place. Again traditional archers won't get clearance, since clearance depends on the timing of the arrow bending left and right. For cut-out risers, the arrow will simply steer tail-high or -low, causing porpoising arrow flight, and you can look at paper tuning for more on this problem.

Either way, too stiff or too limb arrows will cause inaccuracy, and even energy losses. When measuring spine we always measure *static spine*. That is how far it bends due to a precise constant pressure of 1.94 lbs over a 28" section. To measure dynamic spine is quite a different issue. In fact, dynamic spine has two dimensions, how far an arrow bends, and how fast it bends (or vibrates).

Dynamic spine is affected by the following:
1) length: longer arrows will vibrate at a lower frequency - lower dynamic spine, while shorter arrows will vibrate at a higher pitch. It will also cause the arrow to weaken - decreasing the critical load. (+/- 3/4 to one-inch is significant)
2) Weight: a heavier point on the arrow will decrease the frequency, and a light one will increase it. Adding weight to the nock area will also affect frequency in exactly the same way as broadhead weight. A heavier broadhead will decrease the critical load, weight tubes will decrease it but less so, and weight at the nock area will not affect the critical load.
(+/- 25 grains is significant)
3) Poundage: increasing the bow's draw weight require a stiffer dynamic spine
(+/- 2.5 to five pounds is significant)
4) shaft size (diameter and wall thickness)
5) an archer's draw length - certain shafts become significantly weaker when cut past 28 inches
6) string material: for example Dacron strings are slower and require a slightly softer arrow
7) type of bow: recurve or compound with a wheel, soft-cam or speed-cam
8) finger or mechanical release: finger shooters require a slightly stiffer arrow
9) Axle-to-axle length: bows less than 40 inches in length require a slightly stiffer shaft
10) overdraw length, if used: three-inch-plus overdraws require a slightly stiffer arrow.

An arrow that leaves the bow is bending and vibrating. This vibration has a certain frequency and amplitude. The dynamic spine of an arrow is directly related to this **frequency** and **amplitude**. This vibration affects penetration severely. The arrow only stabilize at about 20Y, which means that if you are using marginal equipment, you can actually be too close for the shot.

Weight tubes are special tubes that can be cut to your arrow's length and inserted into the shaft (unless you have a solid shaft). The only function of these tubes is to increase the weight of the arrow. They do not make the arrow stiffer. The dynamic spine of the arrow is not a function of its stiffness alone, but also of its weight, length, and the weight of the broadhead. If you increase the weight of the shaft, the frequency and critical load will change (while static spine, or stiffness, remains unaffected - weight tubes generally does not affect the static spine.) More on this later.

It is also possible to use a second, thin arrow shaft, as weight tube, inside a larger one. This will greatly affect the arrow's weight, and the arrow's static(!) and dynamic spine. For example, one of the stiffer, heavier carbon arrows that is generally available, has a weight of 11.8 gpi, and a spine of 280. This is not heavy enough, and not stiff enough for category 4+ animals! If you build a 29" long arrow with it (for 30" draw length), is should with a 125 grain broadhead end up as 533 grains. To get to 800 grains, you may try a 400gr DIY broadhead - big error. If your bow have a draw weight of 80lbs, it would mean the critical load percentage (CLP) of the arrow is a mere 34% thereof (read on for the definition of CLP). This is WAY below what the manufacturer of the arrow considers save! The heaviest broadhead you can put on such an arrow is 215gr, reaching the minimum 38% CLP, and then you only get to 622 gr total arrow weight, and an arrow that is not very accurate (it will suffer from bending too much, causing the broadhead to steer the arrow everywhere.)

One solution is to use a double arrow as suggested above. To calculate the combined arrow weight of two shafts (or a shaft and a weight tube), just add the gpi's. If the outer shaft is 6.1gpi, and the inner one's 8.3, the final shaft will be very close to 14.4gpi. This results in a total weight of 700gr with a broadhead of 225gr. But can such an arrow carry a 225gr broadhead and an additional 120gr weight (for a total of 811gr)? The outer shaft may have a static spine of 500, and the inner shaft a spine of 400. The combined spine is (400*500/(400+500)) = 222. The critical load for it is 38lbs, which is 47% CLP, which is perfect, almost too stiff. Now adding 3.2gpi weight tubes, or other weighting material in the shaft, you end up with 897gr, and CLP of 47%. (By the way, this arrow will have a FOC of 17% - see Front Of centre for the significance of this.) The starting point for our discussion on how far it will bend is to use the *critical load* under which it will buckle. This is the critical load we mentioned above. The effect of the string on the arrow is to bend it. More power will bend it more, but not faster. The amplitude of the vibration is determined by the force you apply to the arrow (in fact by the force of the arrow on itself because of being accelerated, but that is getting too technical), its length, weight and stiffness. The frequency of the vibration is not. The critical force that buckles the arrow is defined by Euhler as:

$$F_c = \frac{K}{S\,L} \cdot \frac{W_t}{\sum W_i \cdot L_i} \quad ; k = 5,000,000$$

where W_t is the total arrow weight, W_i is the weight of each arrow part, L_i is how far each part's centre of gravity is from the nock point, S is static spine, and L is the length of the arrow. The answer, F_c, is in pounds.

If you would like to calculate the equivalent of spine for this critical load, you can use

    Dynamic Buckling Spine = 12755 / F_c

The constant was chosen such that the dynamic buckling spine for an arrow (28", spine 350, 10gpi) without any broadhead is the same as the static spine, 350. But this is not a very useful value. Rather see what we can do with the critical load...

The buckling load, as a percentage of the bow's maximum draw weight, the *critical load percentage* (CLP), should not be less than 38%. Less than this and the arrow bends too much, and may break, which can have severe health implications. The maximum above which the arrow becomes "too" stiff, is about 51%. Too stiff arrows are generally less accurate than properly spined arrows, but poses no risk. If a compound bow is well tuned however, even WAY too stiff arrows can work.

Reports were received of a CLP over 200% that is still accurate. When thinking this over, you may realize that the weight of a shaft relates only to the spine, if the shaft was built as light as possible - think material limitations. Above the minimum weight, it is independent of the static spine. But increasing the shaft weight does increase the dynamic spine. This is because the arrow accelerates slower if it's heavier, for the same draw weight. Remember, the arrow actually bends because it is compressed between the string, and the g-forces of the broadhead and shaft.Since the g-forces are less if it accelerates slower, this compression force is less. Also, this compression force is translated into the lateral force that bends the shaft, and since the shaft is heavier, the same force would have bend it less - more mass to move. At the same time we just said the force is actually less. Therefore, the displacement of the shaft is less. The heavier arrow, with the same static spine, actually has a stiffer dynamic spine. This in effect decreases the attack angle of the broadhead, and so increases accuracy.

Another approach is to model the arrow as two stiff but weightless rods, connected with a hinge, where the hinge has a certain weight, and contains a spring that keeps it straight.
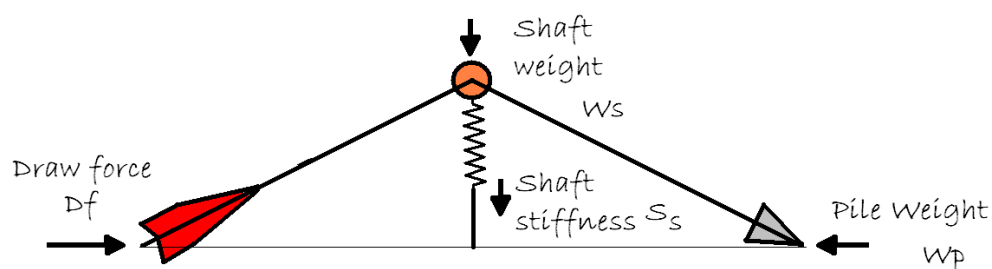
Important to notice is that the arrow bends not according to the bow's draw weight, but according to the "g-forces" it experiences being accelerated. This force is twice the product of the arrow's pile weight and acceleration. Also notice that weight behind any point on the arrow's shaft, cannot add to the weight that bends the part behind it, but instead adds to the weight that resists the bend. Therefore the total weight that bends the arrow is the pile weight plus about half of the shaft weight (Wp + Ws/2). Also the fraction (R) of the force that bends the arrow is proportional to the ratio of the already existing deflection, to half the distance from the nock to the point:

The fraction of the axial force (Fa) that is available to bend the arrow is of course zero if the arrow is perfectly straight and infinitely large if the arrow is bent all the way.

Shaft Length / 2
L/2

Deflection
$$D = FL^3 / 48\ EI$$

$$R = \dfrac{D}{\sqrt{(L/2)^2 - D^2}}$$

$$\sqrt{(L/2)^2 - D^2}$$
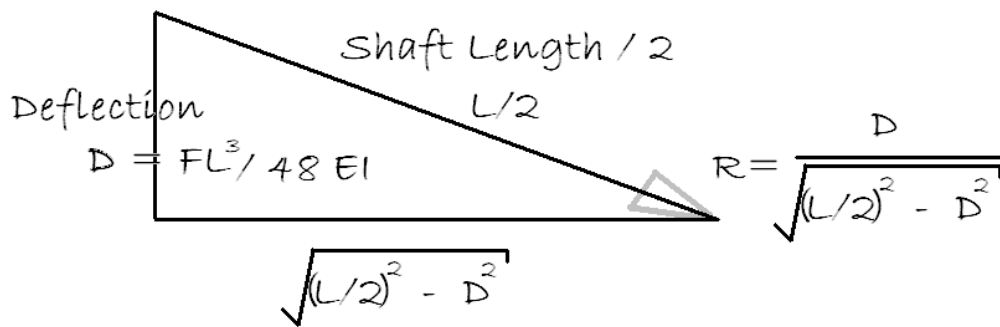
The spine, modeled as a spring, resists this bending force, and this resistance increases with the deflection. If the shaft is perfectly straight then the curve of the axial force needed to bend the arrow starts of at its critical buckling force, and decreases as you bend the arrow. To see if this makes sense, we can draw a curve of the deflection and compare it to the axial force needed to bend the arrow. More realistic, if the arrow is not perfectly straight, or the force is slightly off centre, the axial force curve looks like the one shown here. Calculating the critical buckling force the arrow, in this case, 47.2 lbs (calculated by the approximation done by Euhler's equation), we can see that it closely resembles the curve's maximum of about 45lbs.

$$F_a = \tfrac{1}{2} F \cdot R$$
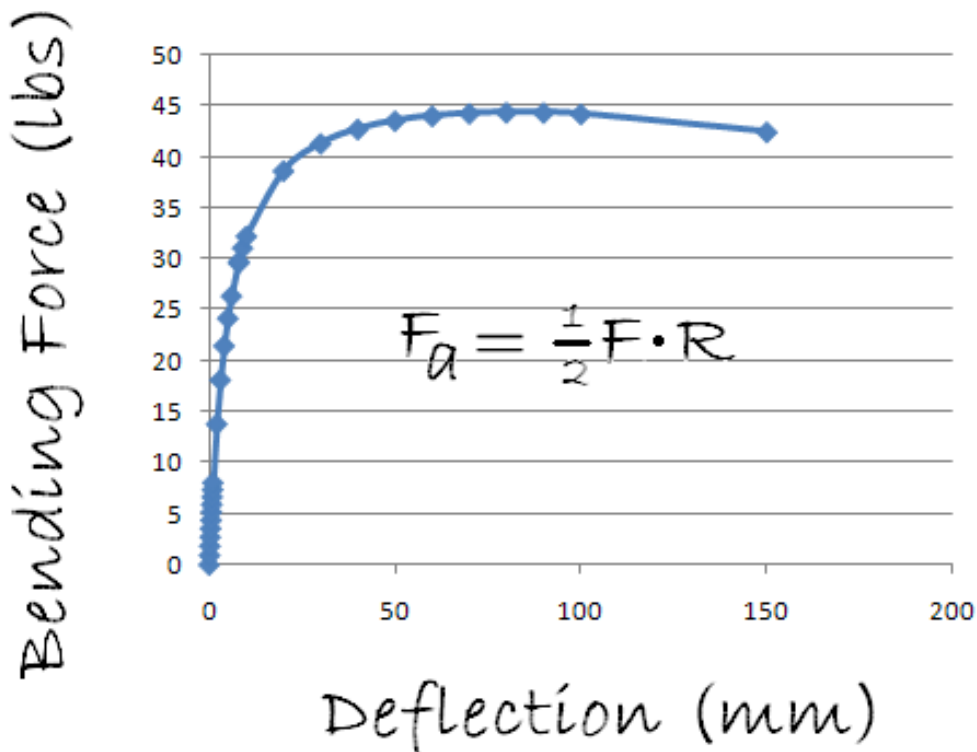
Another interesting feature of this model is the decrease of the resistance against deflection as the arrow is bent beyond a certain point. This resembles the catastrophic failure of an arrow that is pushed too hard - it reaches a point where the arrow needs less force to bend it further than it is currently supporting, and collapses.

The neto-bending force is of course Fg - Fa, where Fg is the g-force experienced during release. The last piece in this puzzle is to apply this force to the weight of the part of the shaft that is being deflected, which is approximately Ws/2. You will recall I mentioned earlier that any mass in front of a certain point on the shaft bends it, and the mass behind this spot resist the bend. If you add all the weights before and after all points on the shaft, you will see that the shaft weight adding to the bending force is half of the shaft weight, and the part that resists it is the other half of the shaft weight.
If we take these forces and apply them for a fraction of a millisecond to the

model each time, until the arrow escapes the string, we can calculate how far it bends.

Using a bow and arrow with the following specifics as a basis, each parameter was changed in turn, so that we can see how the model's prediction on d-spine changes: s-Spine: 300, Draw weight: 70lbs, Arrow rest to within 0.5mm centre shot, Nock travel within 3mm of a straight line, Broadhead 100gr, shaft weight 10gpi, shaft length 30 inches, and Arrow's straightness < 0.006

The "initial deflection" is again an approximation, to accommodate a number of "impe

The arrow speed was calculated with an adaptation of the virtual mass model that rel

Parameter changed	Range	Deflection (mm)
Draw weight	50 to 90 lbs	4.6 to 12.8
Broadhead weight	65gr to 200gr	7.1 to 10.6
Spine	200 to 600	3.8 to 15.3
Shaft Weight (gpi)	6 to 14gpi	10.4 to 7
Shaft length	26" to 32"	5.2 to 9.7
Arrow Straightness	0.006 to 0.001	8.4 to 8.0
Arrow Rest	0 to 2 mm out of place	7.2 to 11.8
Nock travel	1 to 4 mm deviation	3.8 to 10.7

There are many and varied factors influencing dynamic spine. The model presented here, based on a simple interpretation of Newton's laws of motion and numerical analysis, predicts the effect of most of these parameters. The prediction of the bending of the shaft during release may not be extremely accurate, however the changes in the bending is fairly consistent with what would be expected from a real arrow.
The bigger influences on d-spine are the straightness of nock travel, arrow rest tuning, draw weight, broadhead weight and s-spine. The smaller influences are made up of shaft straightness, weight and length.
And this brings me to the answer of why arrows seem to do the Mambo sometimes... bow hand torque, bow heeling, pulling or pushing the bow, all moves the nock and rest relative to each other during the release. As you saw the model predicts that this has a major effect on how much the arrow bends when it is released! Therefore, the d-spine is affected by release form!
But this model and equations are not helping us a lot. What we really want to know is what s-spine should I use for my bow, and when I get the nearest available s-spine, to what length should I cut it. Here is an empirical equation based on the model that answers this question:

$$D = 3.9e^{-14}\left(Dw^{9/4} \cdot DL^{51/16} \cdot Bh^{-3/4} \cdot Wp^{9/16} \cdot L^{3/4} \cdot Ws^{-15/16} \cdot S^{21/16}\right) + 0.007$$

(Dw draw weight, DL draw length, Bh brace height, Wp pile weight, L shaft length, Ws shaft weight, S spine)

This graph here is a plot to show you how relevant this equation is. 97% of the model's predicted deflection is accounted for by it. As a rough approximation, you could say that the required d-spine is proportional to draw weight squared, draw length cubed, and the square root of the pile weight. It decreases proportionally to shaft weight. The relationship between the other factors is a bit less "integral".

For example, for a pile weight 215gr, gpi 13, spine 280, 30" draw length, 7.25 brace height, 72 lbs and 29" shafts, it predicts a deflection of 8.5 mm. I have a suspicion that this is a fair deflection for a 600gr arrow at 262fps. Easton's spine charts in general try to keep the deflection of the arrow below 10mm. I would suggest you can start at 10mm, and decrease the s-spine of the shafts you test, to about 5mm. The best value will very much depend on your bow, since nock travel, inherent from the bow's design, will place a limit on the stiffest arrow that still group nicely.

Figure: $y = 1.0913x - 0.0175$, $R^2 = 0.9727$
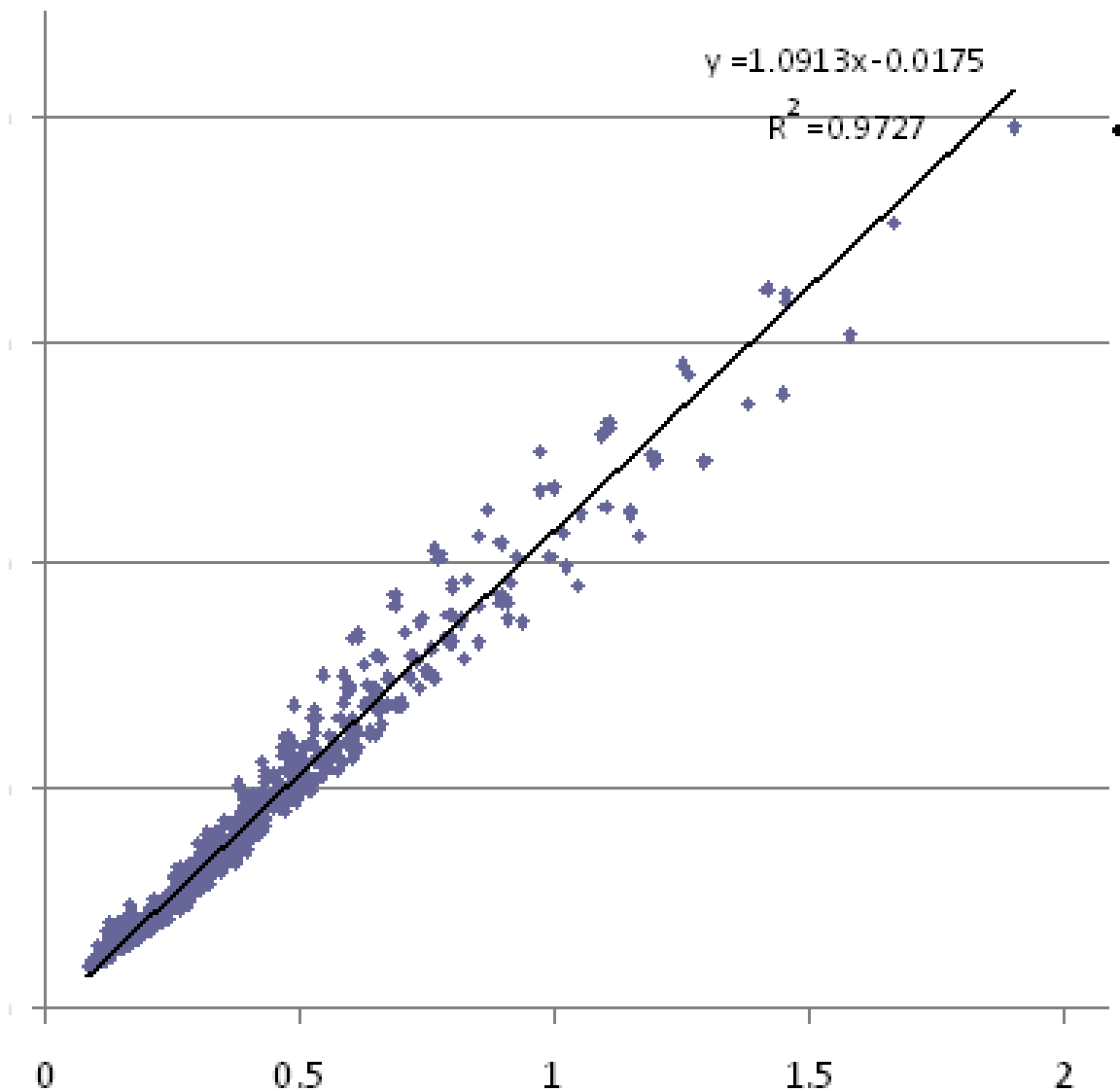
Now let's look at traditional bows and dynamic spine...

How these factors influences the frequency of vibration, is even more complicated. The closest we are able to describe the first fundamental frequency measured by Fourier analysis of a sound recording, is:

$$F_N = 6{,}135{,}788 \times \left(0.5596 + \frac{3}{Wp}\right) / L^2 / \sqrt{S.W_S}$$

Wp is the pile weight of the arrow, L the shaft length, S the s-spine, and Ws the shaft's weight per inch (as GPI).

We have used this equation to predict the frequency of a number of different arrows, and compared this to measurements as made by Bertil Olsson (USA). I was astonished at the accuracy of the results. The total weight of the arrows he tested varied from 291 to 500 grains, the s-spine from 700 to 390, the length from 32.3 to 27.4", and pile weights from 89 to 180gr. The largest error was on the arrow with the smallest shaft weight (5.9gpi), and it was a mere 3.1 Hz more than the measured value of 87.6Hz. The equation describes 98.7% of the measured values - as theories go, this is GOOD.
Here is a table with the experimental results:

Arrow	W_t	L	W_p	W_s	S	F_m	F_p	Error
Wood HPD	500	32.3	126	10.9	550	50.4	49.6	-0.8
X7 1914	375	28.8	100	8.9	660	65.9	64.1	-1.8
XX75 2213	440	30.6	129	9.5	460	67	65.2	-1.8
X72314	525	30	180	10.8	390	68.9	69.3	0.4
Cartel Tri 700	291	29	92	6.1	700	75.8	74	-1.8
ACE 520	292	30.3	89	6.0	520	79.7	78.8	-0.9
ACC 560	325	27.4	103	7.3	560	83.5	85.5	2.0
ACE 520	308	28.5	120	5.9	520	87.6	90.7	3.1

Wt – total arrow weight, L arrow length, Wp pile weight, Ws, shaft weight, Fm measured frequency, Fp – predicted frequency

The next question you will ask now is what frequency is the correct frequency for your bow. Stu Miller has developed and excellent spine calculator for non-compound bows. It has a collection of a huge number of commercial shafts, and he actively keeps this up. You will find it easily with Google. I used this calculator of his to compare results of my model with his empiric formula (empiric: based on describing the relationship and not explaining it). (Just a short reminder: The frequency will determine how fast the arrow vibrates or bend, and therefore how much time it will take to move the fletches out of the way of the riser as it passes to the side of it.)

The draw-force curve for a typical non-compound bow can be approximated to a straight line, increasing from 0# at brace height, to let's say 70# at 29". This would imply that the average acceleration of the arrow will be half the maximum draw force at full draw divided with the total arrow weight. The draw-force curve for these bow designs is usually slightly higher than a straight line, but then we also ignore the string weight and limbs weight, so we hope things equal out. The approximation would suffice for getting a ball park figure.

For our bow, with a brace height of 8", which imply a power stroke of 29-8, 21", and 70/2#, you can expect a 434gr arrow's fletches to take about 16.3 milliseconds to reach the point where it should start to move the fletches away from the riser.

$$ t = \sqrt{2(D-B)/a} + \frac{B}{2}\Big/ \sqrt{2(D-B)a} \;;\; a = \frac{F/2}{W_t} $$

D is draw length, B brace height, F draw weight, and Wt is the total arrow weight.

Now 16.3 milliseconds correspond to 61.2Hz (F=1/t). According to Stu Millers's calculator, the following arrow would have been perfect: Shaft size: 2213, 29" with a 125gr broad head. If we calculate the frequency for this arrow, it comes to 64.4Hz. I am inclined to believe Stu Miller's calculator is correct. The difference between 64.4 and 61.2 Hz (3.2Hz) corresponds to about 0.5" of shaft length. To equalize the frequency exactly, the arrow will need to be 30" long. This difference in frequency represents about 6cm of travel. But here is a table of a view different arrows:

	Wp	Ws	S	DL	Bh	DF	L	Wt	fps	millis	Fn(arrow)	Fn(bow)	Error (Hz)
xx75 2213	150	9.5	460	30	8	50	31.5	449	194	19.8	54.2	50.6	3.7
	125	9.5	460	30	8	60	30.65	416	219	17.5	57.7	57.1	0.5
	100	9.5	460	30	8	70	30.13	386	244	15.7	60.3	63.6	-3.3
1914	150	8.9	660	27	8	46	29.3	411	179	18.6	54.1	53.8	0.3
	150	8.6	660	27	8	56	27.8	389	202	16.5	61.1	60.6	0.5
	125	8.6	660	27	8	65	27.4	361	224	14.9	63.3	67.3	-4.0

These arrows are matched to the bows using Stu Miller's calculator. As you can see the frequencies we predict is slightly different. In the next table, I have matched the arrows to the bows using the frequency. You may notice that according to this prediction, the last arrow may be slightly too short.

	Wp	Ws	S	DL	Bh	DF	L	Wt	fps	millis	Fn
xx75 2213	150	9.5	460	**30**	**8**	**50**	32.8	462	192	20.0	50.0
	125	9.5	460	**30**	**8**	**60**	30.8	418	219	17.5	57.1
	100	9.5	460	**30**	**8**	**70**	29.2	377	246	15.6	64.2
1914	150	8.9	660	**27**	**8**	**46**	29.4	412	179	18.6	53.7
	150	8.6	660	**27**	**8**	**56**	27.91	390	202	16.5	60.6
	125	8.6	660	**27**	**8**	**65**	26.46	353	226	14.7	67.9

All this said and done, if you shoot a compound bow, it's better to err on the too stiff side. And as a general rule: Shoot the stiffest arrow that still groups satisfactory.

Further Reading: JP de Villiers, **AB&A**, Oct 2008, p52, *"FAQ"*
Seppie Celliers, **AB&A**, Dec 2007, p30, *"Arrow Spine"*
Harry Marx, **AB&A**, Mar 2009, p30, *"Dynamic Spine and Building Heavy Arrows"*
Harry Marx, **AB&A**, in press, , *"Dynamic Spine II"*

3.5.8.1.1   Easton Arrow selection charts

These are the charts for Easton and GoldTip. We include it here for *instructional purposes*. Although the specific arrow models change, the s-spine requirements is always relevant.

Arrow Selection Chart

Using the Hunting Arrow Selection Chart

1. Once you have determined your Correct Hunting Arrow Length and Calculated or Actual Peak Bow Weight, you are ready to select your correct shaft size:

1.A Compound bows. In the "Calculated Peak Bow Weight" column (left-hand side of the chart), select the column with the type cam on your bow, then the column with the point weight you use. Then locate your Calculated Peak Bow Weight in that column.

1.B Recurve bows and Modern Longbows. In the "Actual Peak Bow Weight" column (right-hand side of the chart), select the column with the bow type and then the point weight you use. Next, locate your Actual Peak Bow Weight in that column.

2. Move across that bow-weight row horizontally to the column indicating your Correct Arrow Length. Note the letter in the box where your Calculated or Actual Peak Bow Weight row and Correct Hunting Arrow Length column intersect. The "Shaft Size" box below the chart with the same letter contains your recommended shaft sizes. Select a shaft from the chart depending on the shaft material, shaft weight, and type of shooting you will be doing.
For larger game, you should use heavier shafts.

Selecting the Correct Hunting Shaft Size

The Hunting Shaft Selection Chart will help you find the perfect shaft match for your bow— quickly and easily. Advanced, interactive Spine Weight Comparison and Hunting Shaft Selection Charts are now available online at www.eastonarchery.com.

1. Determining Correct Hunting Arrow Length

Bows with cut-out window. The Correct Hunting Arrow Length for bows with a broadhead cut-out sight window (including bows with overdraws) is determined by drawing back an extra-long arrow to full draw and having someone mark the arrow one-to-two inches in front of where

1"-2" clearance (minimum)

Correct Hunting Arrow Length

Belly of bow (face side)

Mark arrow here.

Back of bow (far side)

Note: Correct arrow length is measured from throat (string hole) of the nock to end of the shaft, not including point or insert.

Bottom of nock groove.
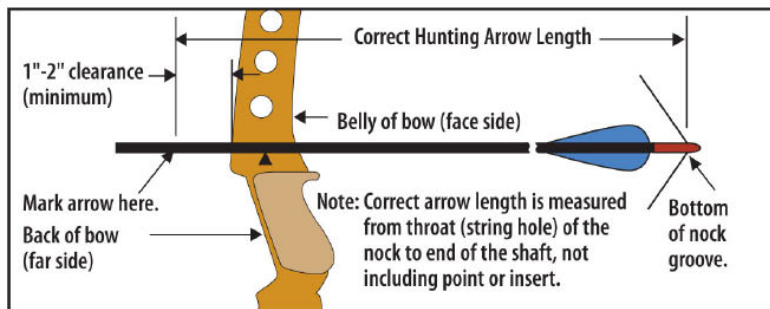
the arrow contacts the most forward portion of the arrow rest.
Bows without cut-out window (which will not allow a fixed blade broadhead to be drawn past the back of the bow). The Correct Hunting Arrow Length for bows without a cut-out sight window is determined by drawing back an extra-long arrow to full draw and having someone

1"-2" clearance (minimum)

Correct Hunting Arrow Length

Mark arrow here.

Place where arrow contacts most forward portion of the arrow rest.

Back of bow (far side)

Belly of bow (face side)

Bottom of nock groove.
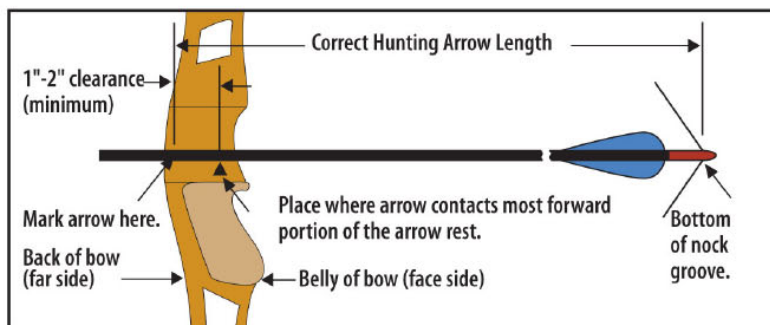
mark the arrow one-to-two inches in front of the handle.
Bow Draw Length. Draw length is measured at full draw from the bottom of the nock groove to the back (far side) of the bow. Actual arrow length and draw length are only the same if the end of the arrow shaft is even with the back of the bow (far side) at full draw.

2. Determining Actual Peak Bow Weight—Compound Bows

Compound bows must be measured at the peak bow weight as the bow is being drawn and not while letting the bow down.

The suggested shaft sizes in the charts were determined using a **"Standard" Setup** which includes:

- Use of a release aid
- Compound bow with brace height greater than 6½"

If your setup differs from the **"Standard" Setup**, use the **Variables** (following) to make adjustments to determine the Calculated Peak Bow Weight so the correct arrow size can be selected on the chart.

Variables to the "Standard" Setup for Compound Bows:

- Point weight over 100 grains – Add 3 lbs. for each 25 grains heavier than 100 grains.
- Bows with brace heights less than 6½" – Add 5 lbs.
- Finger release – Add 5 lbs.

Overdraw Compound Bows

If you are using an overdraw, make the variable calculations (if any), and then modify the Calculated Peak Bow Weight of your bow using the chart below.

Length of Overdraw

Bow Weight	1"	2"	3"	4"	5"
For 50#–70# Actual/Calculated Peak Bow Weight, add to bow weight—	1#	3#	6#	9#	12#

3. Determining Actual Peak Bow Weight—Recurve and Modern Longbows

Your local archery pro shop is the best place to determine the actual draw weight of your bow. Actual Peak Bow Weight for recurve bows should be measured at your draw length.

COMPOUND BOW - Release Aid
Calculated Peak Bow Weight - lbs.

Medium Cam · **Single or Hard Cam**

Correct Hunting Arrow Length

Medium Cam — Point Weight				Single or Hard Cam — Point Weight				Correct Hunting Arrow Length										
75 (grains) 65-85	**100** (grains) 90-110	**125** (grains) 115-135	**150** (grains) 140-160	**75** (grains) 65-85	**100** (grains) 90-110	**125** (grains) 115-135	**150** (grains) 140-160	22½ **23"** 23½	23½ **24"** 24½	24½ **25"** 25½	25½ **26"** 26½	26½ **27"** 27½	27½ **28"** 28½	28½ **29"** 29½	29½ **30"** 30½	30½ **31"** 31½	31½ **32"** 32½	32½ **33"** 33½
				35-39	32-36	29-33	26-30			A	A	B	B	C	C	D	E	F
40-44	37-41	34-38	31-35	40-44	37-41	34-38	31-35		A	B	B	C	C	D	E	F	F	G
45-49	42-46	39-43	36-40	45-49	42-46	39-43	36-40	A	B	B	C	C	D	E	F	F	G	H
50-54	47-51	44-48	41-45	50-54	47-51	44-48	41-45	B	B	C	C	D	E	F	G	G	H	I
55-59	52-56	49-53	46-50	55-59	52-56	49-53	46-50	B	C	C	D	E	F	G	H	H	I	J
60-64	57-61	54-58	51-55	60-64	57-61	54-58	51-55	C	C	D	E	F	G	H	I	I	J	K
65-69	62-66	59-63	56-60	65-69	62-66	59-63	56-60	C	D	E	F	G	H	I	J	J	K	L
70-75	67-72	64-69	61-66	70-75	67-72	64-69	61-66	D	E	F	G	H	I	J	K	K	L	M
76-81	73-78	70-75	67-72	76-81	73-78	70-75	67-72	E	F	G	H	I	J	K	L	L	M	M
82-87	79-84	76-81	73-78	82-87	79-84	76-81	73-78	F	G	H	I	J	K	L	L	M	M	
88-93	85-90	82-87	79-84	88-93	85-90	82-87	79-84	G	H	I	J	K	L	L	M			
94-99	91-96	88-93	85-90	94-99	91-96	88-93	85-90	H	I	J	K	L	L	M				
100-105	97-102	94-99	91-96	100-105	97-102	94-99	91-96	I	J	K	L	L	M					

RECURVE BOW
Finger Release

actual peak Bow Weight - Lbs. — Point Weight

MODERN LONGBOW
Finger Release

actual peak Bow Weight - Lbs. — Point Weight

Correct Hunting Arrow Length

RECURVE BOW — actual peak Bow Weight - Lbs.				MODERN LONGBOW — actual peak Bow Weight - Lbs.				Correct Hunting Arrow Length										
75 (grains) 65-85	**100** (grains) 90-110	**125** (grains) 115-135	**150** (grains) 140-160	**75** (grains) 65-85	**100** (grains) 90-110	**125** (grains) 115-135	**150** (grains) 140-160	**23"** 22½ 23½	**24"** 23½ 24½	**25"** 24½ 25½	**26"** 25½ 26½	**27"** 26½ 27½	**28"** 27½ 28½	**29"** 28½ 29½	**30"** 29½ 30½	**31"** 30½ 31½	**32"** 31½ 32½	**33"** 32½ 33½
				41-46	38-43	35-40	32-37			A	A	B	B	C	C	D	E	F
				47-52	44-49	41-46	38-43		A	A	B	B	C	C	D	E	F	G
35-39	32-36	29-33	26-30	53-58	50-55	47-52	44-49	A	A	B	B	C	C	D	E	F	G	H
40-44	37-41	34-38	31-35	59-64	56-61	53-58	50-55	A	B	B	C	C	D	E	F	G	H	I
45-49	42-46	39-43	36-40	65-70	62-67	59-64	56-61	B	B	C	C	D	E	F	G	H	I	J
50-54	47-51	44-48	41-45	71-76	68-73	65-70	62-67	B	C	C	D	E	F	G	H	I	J	K
55-59	52-56	49-53	46-50	77-82	74-79	71-76	68-73	C	C	D	E	F	G	H	I	J	K	L
60-64	57-61	54-58	51-55	83-88	80-85	77-82	74-79	C	D	E	F	G	H	I	J	K	L	M
65-69	62-66	59-63	56-60	89-94	86-91	83-88	80-85	D	E	F	G	H	H	I	J	K	L	M
70-75	67-72	64-69	61-66	95-100	92-97	89-94	86-91	E	F	G	H	H	I	J	K	L	L	M
76-81	73-78	70-75	67-72	101-106	98-103	95-100	92-97	F	G	H	H	I	J	J	K	L	L	M
82-87	79-84	76-81	73-78	107-112	104-109	101-106	98-103	G	H	H	I	J	J	K	L	L	M	M
88-93	85-90	82-87	79-84	113-118	110-115	107-112	104-109	H	I	J	J	K	L	L	L	L	M	M
94-99	91-95	88-93	85-90	119-124	116-121	113-118	110-115	I	J	J	K	L	L	L	L	M	M	M

Group A

Size	Spine @ 28"Span	Model	Weight Grs/Inch	Weight @29"
1813	0.874	75	7.9	229
1716	0.880	75	9.0	261
780	0.780	Rdln	6.3	183

Group E

Size	Spine @ 28"Span	Model	Weight Grs/Inch	Weight @29"
2212	0.505	SS	8.8	255
2114	0.510	SS,75	9.9	287
2018	0.464	75	12.3	357
500	0.500	GG	10.6	307
500	0.500	AFMJ	9.1	264
500	0.500	Crbn	CarbWt	CarbWt
520	0.520	Rdln	7.1	206

Group I

Size	Spine @ 28"Span	Model	Weight Grs/Inch	Weight @29"
2413	0.365	SS,75	10.4	302
2314	0.390	SS,75	10.7	310
2315	0.340	SS,75	11.7	339
2216	0.375	SS,75	12.0	348
400	0.400	GG	12.0	348
400	0.400	AFMJ	10.2	296
390	0.390	ACCPro	8.9	258
400	0.400	Crbn	CarbWt	CarbWt
410	0.410	Rdln	7.6	220

Group M

Size	Spine @ 28"Span	Model	Weight Grs/Inch	Weight @29"
1613	0.265	SS	11.5	334
2419	0.628	75	14.6	423
300	0.300	ACCPro	10.4	302
250	.250	DngrGame	17.2	499

Group B

Size	Spine @ 28"Span	Model	Weight Grs/Inch	Weight @29"
1913	0.733	75	8.3	241
1816	0.756	75	9.3	270
690	0.690	Rdln	6.3	183

Group F

Size	Spine @ 28"Span	Model	Weight Grs/Inch	Weight @29"
2212	0.505	SS	8.8	255
2213	0.460	SS,75	9.8	284
2018	0.464	75	12.3	357
500	0.500	GG	10.6	307
500	0.500	AFMJ	9.1	264
440	0.440	ACCPro	8.4	244
500	0.500	Crbn	CarbWt	CarbWt
520	0.520	Rdln	7.1	206

Group J

Size	Spine @ 28"Span	Model	Weight Grs/Inch	Weight @29"
2512	0.321	SS	10.3	299
2413	0.365	SS,75	10.4	302
2315	0.340	SS,75	11.7	339
2219	0.337	SS,75	13.8	400
340	0.340	GG	11.7	339
340	0.340	AFMJ	11.3	328
340	0.340	ACCPro	9.7	281
360	0.360	Crbn	CarbWt	241

Group C

Size	Spine @ 28"Span	Model	Weight Grs/Inch	Weight @29"
2013	0.610	75	9.0	261
1916	0.623	75	10.0	290
600	0.600	Rdln	6.9	200
520	0.520	Crbn	CarbWt	CarbWt

Group G

Size	Spine @ 28"Span	Model	Weight Grs/Inch	Weight @29"
2312	0.423	SS	9.5	276
2215	0.420	SS,75	10.7	310
2217	0.400	75	12.0	348
2020	0.426	GG	13.5	392
400	0.400	AFMJ	12.0	348
400	0.400	GG	12.0	348
440	0.440	ACCPro	8.4	244
400	0.400	Crbn	CarbWt	CarbWt
460	0.460	Rdln	7.3	212

Group K

Size	Spine @ 28"Span	Model	Weight Grs/Inch	Weight @29"
2512	0.321	SS	10.3	299
2514	0.305	SS,75	11.3	328
2317	0.297	SS,75	13.3	386
2419	0.268	75	14.6	423
340	0.340	GG	13.3	386
340	0.340	AFMJ	12.0	348
300	0.300	ACCPro	10.4	302
300	0.300	Crbn	CarbWt	CarbWt
250	0.250	DngrGame	15.5	450

Group D

Size	Spine @ 28"Span	Model	Weight Grs/Inch	Weight @29"
2016	0.531	75	10.6	307
500	0.500	GG	10.6	307
500	0.500	AFMJ	9.1	264
500	0.500	Crbn	CarbWt	CarbWt
520	0.520	Rdln	7.1	206

Group H

Size	Spine @ 28"Span	Model	Weight Grs/Inch	Weight @29"
2215	0.420	SS,75	10.7	310
2314	0.390	SS,75	10.7	310
2217	0.400	75	12.0	348
2216	0.375	SS,75	12.0	348
400	0.400	GG	12.0	348
400	0.400	AFMJ	10.2	296
390	0.390	ACCPro	8.9	258
400	0.400	Crbn	CarbWt	CarbWt
410	0.410	Rdln	7.6	220

Group L

Size	Spine @ 28"Span	Model	Weight Grs/Inch	Weight @29"
2514	0.305	SS,75	11.3	328
2613	0.265	SS	11.5	334
2317	0.297	SS,75	13.3	386
75		75	14.6	423
340		GG	13.3	386
340		AFMJ	12.0	348
300		ACCPro	10.4	302
300		Crbn	CarbWt	CarbWt
250	0.250	DngrGame	17.2	499

Key

Size – indicates suggested arrow size

Spine – spine of shaft size shown (static)

CarbWt – refer to Carbon box (left) for specific model and weight

Color Designation for Aluminum Arrows – Within each box the aluminum arrows are color coded.

☐ = lightest and fastest
☐ = medium weight offering good speed and durability
☐ = heavier weights for excellent durability and penetration
☐ = aluminum/carbon and carbon

AFMJ	Axis Full Metal Jacket & Axis Full Metal Jacket Camo
DngrGame	Axis Full Metal Jacket Dangerous Game
SS	Super Slam Digital (7178-19 alloy)
75	XX75: Realtree HD Green, Legacy, Camo Hunter, (7075-19 alloy)
GG	Game Getter
ACCPro	Aluminum/Carbon/Composite Pro Hunting
Rdln	Redline
Crbn	ST Axis, ST AXIS RT, ST Excel, ST Epic, ST Epic RT HD, Flatline, PowerFlight

Note: Shaft Weight at 29" is shown on our Arrow Selection Charts. To determine weight at your shaft length, multiply your actual shaft length by the grains-per-inch (gpi), not including point, insert, or UNI Bushing.

Carbon Shaft Weights (CarbWt)

Size	Spine	ST Axis N-Fused		ST Axis N-Fused Camo		ST Epic N-Fused		ST Epic N-Fused Camo		Flatline		ST Excel		PowerFlight	
		Grs/In	@29"	Grs/In	@29"	Grs/In	@29"	Grs/In	@29"	Grs/In	@29"	Grs/In	@29"	Grs/In	@29"
600	0.600	—	—	—	—	6.4	186	—	—	—	—	—	—	—	—
500	0.500	8.1	235	8.9	258	7.3	212	8.0	232	6.5	189	7.3	212	7.3	212
400	0.400	9.0	261	9.8	284	8.6	249	9.3	270	7.4	215	8.6	249	8.9	244
340	0.340	9.5	276	10.3	299	9.5	276	10.2	296	8.2	238	9.5	276	9.3	270
300	0.300	10.7	310	11.5	334	10.0	290	10.7	310	—	—	10.0	290	9.5	276

DRAW WEIGHT	85 GRAIN POINT										100 GRAIN POINT										125 GRAIN POINT										TRADITIONAL									
	23"	24"	25"	26"	27"	28"	29"	30"	31"	32"	23"	24"	25"	26"	27"	28"	29"	30"	31"	32"	23"	24"	25"	26"	27"	28"	29"	30"	31"	32"	23"	24"	25"	26"	27"	28"	29"	30"	31"	32"
30-35	1	1	1	1	1	1	2	2	2/3	3/4	1	1	1	1	1	2	2	2/3	3/4	4	1	1	1	1	2	2	2/3	3/4	4	4	1	1	1	1	1	1	1	2	2	2/3
35-40	1	1	1	1	1	2	2	2/3	3/4	4	1	1	1	1	2	2	2/3	3/4	4	4	1	1	1	2	2	2/3	3/4	4	4	5	1	1	1	1	1	2	2	2/3	3/4	4
40-45	1	1	1	1	2	2	2/3	3/4	4	4	1	1	1	2	2	2/3	3/4	4	4	5	1	1	2	2	2/3	3/4	4	4	5	5	1	1	1	1	2	2	2/3	3/4	4	4
45-50	1	1	1	2	2	2/3	3/4	4	4	5	1	1	2	2	2/3	3/4	4	4	5	5	1	2	2	2/3	3/4	4	4	5	5		2	2	2	2	2	2	2/3	3/4	4	4
50-55	1	1	2	2	2/3	3/4	4	4	4	5	1	2	2	2/3	3/4	4	4	5	5	5	2	2	2/3	3/4	4	4	5	5	5		2	2	2	2	2	2	2/3	3/4	4	4
55-60	1	2	2	2/3	3/4	4	4	4	5	5	2	2	2/3	3/4	4	4	5	5	5		2	2/3	3/4	4	4	5	5	5	6		2	2	2	2	2/3	3/4	4	4	5	
60-65	2	2	2/3	3/4	4	4	5	5	5		2	2/3	3/4	4	4	5	5	5	6		2/3	3/4	4	4	5	5	5	6			2	2	2/3	3/4	4	4	5	5		
65-70	2	2/3	3/4	4	4	5	5	5	6		2/3	3/4	4	4	5	5	5	6	6		3/4	4	4	5	5	5	6	6	6		2	2	2/3	3/4	4	4	5	5	5	
70-75	2/3	3/4	4	4	5	5	5	6	6		3/3	4	4	5	5	5	6	6	6		3/4	4	4	5	5	5	6	6	6	7	2	2/3	3/4	4	4	5	5	5	6	
75-80	3/4	4	4	5	5	5	6	6	6		3/4	4	4	5	5	5	6	6	6		3/4	4	4	5	5	5	6	6	7	7	2/3	3/4	4	4	5	5	5	6	6	
80-85	4	4	4	5	5	5	6	6	6	7	4	4	5	5	5	6	6	6	7	7	5	5	5	5	6	6	6	7	7	7	3/4	3/4	4	4	5	5	5	6	6	6
85-90	4	4	5	5	5	6	6	6	7	7	5	5	5	5	6	6	6	7	7	7	5	5	5	6	6	6	7	7	7	7	3/4	4	4	5	5	5	6	6	6	7
90-95	5	5	5	5	6	6	6	7	7	7	5	5	5	6	6	6	7	7	7	7	5	5	6	6	6	7	7	7	7	7	4	4	5	5	5	6	6	6	7	7
100+	5	5	5	6	6	6	7	7	7	7	5	5	6	6	6	7	7	7	7	7	5	6	6	6	7	7	7	7	7	7	5	5	5	5	6	6	6	7	7	7

GROUP 1 SHAFTS	SIZE	SPINE
Traditional	1535	.600"
Ultralight	600	.600"

GROUP 2 SHAFTS	SIZE	SPINE
Expedition Hunter	3555	.500"
Falcon 35	35	.500"
Pro Hunter	3555	.500"
Traditional	3555	.500"
Ultralight	500	.500"
Vapor Pro	500	.500"
Vapor Hunter	500	.500"
XT Hunter	3555	.500"

GROUP 3 SHAFTS	SIZE	SPINE
CAA *	450	.440"

GROUP 4 SHAFTS	SIZE	SPINE
Expedition Hunter	5575	.400"
Pro Hunter	5575	.400"
Traditional	5575	.400"
Ultralight	400	.400"
Vapor Pro	400	.400"
Vapor Hunter	400	.400"
XT Hunter	5575	.400"

GROUP 5 SHAFTS	SIZE	SPINE
Expedition Hunter	7595	.340"
Pro Hunter	7595	.340"
XT Hunter	7595	.340"

GROUP 7 SHAFTS	SIZE	SPINE
Big Game	100+	.280"
X-Cutter	24/64	.250"

GROUP 6 SHAFTS	SIZE	SPINE
Series-22	22/64	.300"
Traditional	7595	.300"
Ultralight	300	.300"
Vapor Pro	300	.300"
Vapor Hunter	300	.300"

3.5.8.2   Arrow Spin

Another major influence on arrow stability is of course arrow spin. The way in which it affects stability has little to do with the so called gyro-effect. When the arrow leaves the string, it starts to turn, if the fletching is helical or at an angle. During this process the energy to spin the arrow is drawn from the arrow's speed by causing a drag at the back of the arrow. This "pulls" the arrow at its tail backwards, and straightens it.

```
Once the arrow's spin reaches the rotational speed at which  it  can't  be  spun
quicker, due to the angle of the fletching, this drag falls away, and the  arrow
no longer loses speed to spin it. If the arrow now looses speed due  to  gravity
or friction, it can actually be spinning faster than  its  fletching  angle  and
speed  dictates.  This  can  decrease  the  stability  of  the  arrow  at   long
distances(>60Y), as it moves the centre  of  pressure  forwards.  Quantifying
this effect has been attempted, but for now you should just take  note  of  this
effect.
```

Another effect the spin has on arrow flight is to limit the influence of unbalanced aerodynamic forces. Such a force would cause the un-spinning arrow to fly in a curving trajectory. When it spins, this curvature is controlled by now forcing the arrow into a helical trajectory. This does increase accuracy, but not penetration. For penetration you need an arrow which flies straight.

```
Increasing the size or angle of the fletching usually only works  to  a  certain
degree. Then the increased rotation speed actually causes this unbalanced  arrow
to start to wobble. It is therefore not wise to try  and  stabilize  an  already
wobbling arrow with bigger fletches. The  better  solution  is  to  balance  the
arrow, or to get rid of it. If the unbalance is due to the  broadhead,  you  can
try another broadhead on it.  Sometimes it's  due  to  the  "insert"  not  being
inserted straight. Mostly it's due to a used broadhead that bent slightly during
a previous shot. Spinning the arrow on its tip or in an  arrow  spinner  usually
detects such an unbalance. Sometimes you only  see  it  as  a  unwillingness  to
group.

A small hint - you can number each arrow, and keep track of where each arrow
tends to group. Sometimes, arrows group very well, just  not  all  at  the  same
spot.

Fritz Rabe, has another angle on arrow stability:
"In bowhunting we try to get as close as possible to an animal to make a good
shot. Very few hunters realize that to  get  to  close  can  hamper  penetration
especially when your target is a big tough animal like the Pachyderms,  Buffalo,
Crocodile and Giraffe.
```

This is because the arrow flexes after release. Different arrows with different set-ups all flexes differently. If your arrow encounters resistance while it is still flexing it can reduce penetration up to 70%. This all depends on the power of the bow compared to the arrow. This walks hand in hand with spine.

```
The spine of an arrow must match the bow to start of with. In hunting, the spine
must also match the resistance especially in heavy bows with fast  arrows.  Most
spine charts give the spine stiffness for acceleration. This is fine for  target
shooting but not for hunting. In hunting, the arrow sometimes come to a stop  in
a shorter distance than it accelerate out of the bow, [for eg. when] striking  a
bone.

Combine this last fact with a to close distance from the target and you will
have zero penetration even from a good set-up.
```

Every set-up has a "sweet-spot" where it will get maximum penetration. This is normally between 18 - 33 yards. The heavier the arrow and power of the bow, the longer it takes to stabilize the arrow. That is why it is a good idea to get the FOC of the arrow as much forward as possible and to use long helical fletching. A lot of people use short 2" - 3" fletches today and it works well to achieve speed and it does group etc. but it takes a long time to fully stabilize an arrow. The arrow also looses a lot of its energy during flexing that could have been put to better use.

```
The less an arrow flex, the more momentum it has. The faster it stabilizes the
```

better it flies."

Further Reading: John Dudley, **AB&A**, Mar 2008, p30, *"The Best Fletching For your Arrows"*
JP de Villiers, **AB&A**, Mar 2008, p48, *"FAQs"*
Sampie Stoffberg, **AB&A**, Jan 2009, p56, *"Die keuse van vere"*

3.6   Implementing all the theory

We have a calculator available for MS Excel, which can simplify these decisions. We also have a program that extends this and lists the animals that are within these recommendations in relation to your equipment SABA Hunt Calculator

Here is a screen shot from the main page. This page describes the penetration of a particular arrow for all categories.

You merely enter the data of the arrow, the broadhead, and your grouping. It then uses all this nice maths, and show you the result in the coloured % column. According to these principles 80% of the recommendation is on the border of being acceptable, while 100% should on average result in a full traversal of the animal's chest cavity.

4   In Practice

The hunter should practice from kneeling and sitting positions (on a chair and on the ground) to shoot. Most often when stalking an animal, you will be shooting from a very unnatural position. This can severely affect your

accuracy.

4.1   Using a bow

Further Reading: Seppie Celliers, **AB&A**, Jan 2007, p42, *"Boogterme"*
Rean Steenkamp, **AB&A**, Apr 2007, p47, *"Eye Dominance"*

4.1.1   Tuning a bow

A bow and arrow is a complicated machine that needs expert tuning for optimal hunting performance. We recommend that a bow hunter should practice to shoot accurately with the highest poundage possible. It is recommended that the bow is tuned in order to maximize the energy transferred from the bow to the arrow. Thus the right selection of combined optimal equipment is critical and each component of the bow hunting set-up must be carefully selected.

We will discuss tuning a bow in the order that you will need to perform it.

4.1.2   Cam Tuning

Although cam tuning is (almost) always done in the shop, you need a bow press and a bow shooting machine, we discuss it here for the importance of this step. And contrary to popular hype, even binary cams needs to be tuned. Of course this does not apply to single cams...

Tuning cams is done basically to synchronize the cams. As the cams rotate, the leverage they gain when moving out of the valley, will cause the one that comes out first, to roll up the string first and basically to starve the other cam. The starved cam is then slowed down even more. This of cause causes very uneven nock travel. Not only does this cause all types of vibrations in the bow and the arrow (reads loss of energy), the arrow's vibrations in turn causes a loss accuracy.

The cams are tuned by changing the relative lengths of the two bus cables. First you must draw the bow on the shooting machine. You can do it drawing the bow with your arms, but you will need a friend to check the rotation, and it is not as convenient or accurate. But the idea is to notice how far the cams rotate, especially going into the value and reaching the back wall. Look at the gaps between the rotation stoppers, the back wall, and the strings. They should be the same.

If they are not the same, you need to start tuning. This involves taking the tension of the bus cables using a bow press, just enough to unhook one loop of one of the bus cables. Winding the cable up or down just a half turn can have a big effect.
Hook it again, remove the bow and go and shoot 10 shots for the string to settle again.

Then you check the rotation of the cams again on the shooting machine.

4.1.3   Paper Tuning

The purpose of paper tuning is to set the arrow rest's height and the preliminary lateral position. You need to do paper tuning, and then "walk back tuning", to get good flight from arrows with hunting points.

The rest is initially set up with the arrow going through the "centre shot" position of the riser. Your bow shop will usually help with this.

Paper tuning is done with field points. A large paper, a news paper will do, is hung at about 2Y from the butt. The arrow is then shot from about 2 to 10Y through the paper into the butt. The arrow should make a round "bullet"-hole for the shaft, with the flights cuttings three radiating spokes for it. If the arrow were not travelling straight, where the point went through for ex. to the left of the flights, you'll see the flights tearing three thin tears to the right of a thicker horizontal tear made by the shaft.

Further Reading: JP de Villiers, **AB&A**, Nov 2008, p52, *"FAQ"*
Herman Brand, **AB&A**, Sep 2007, p13, *"Paper tuning your bow"*
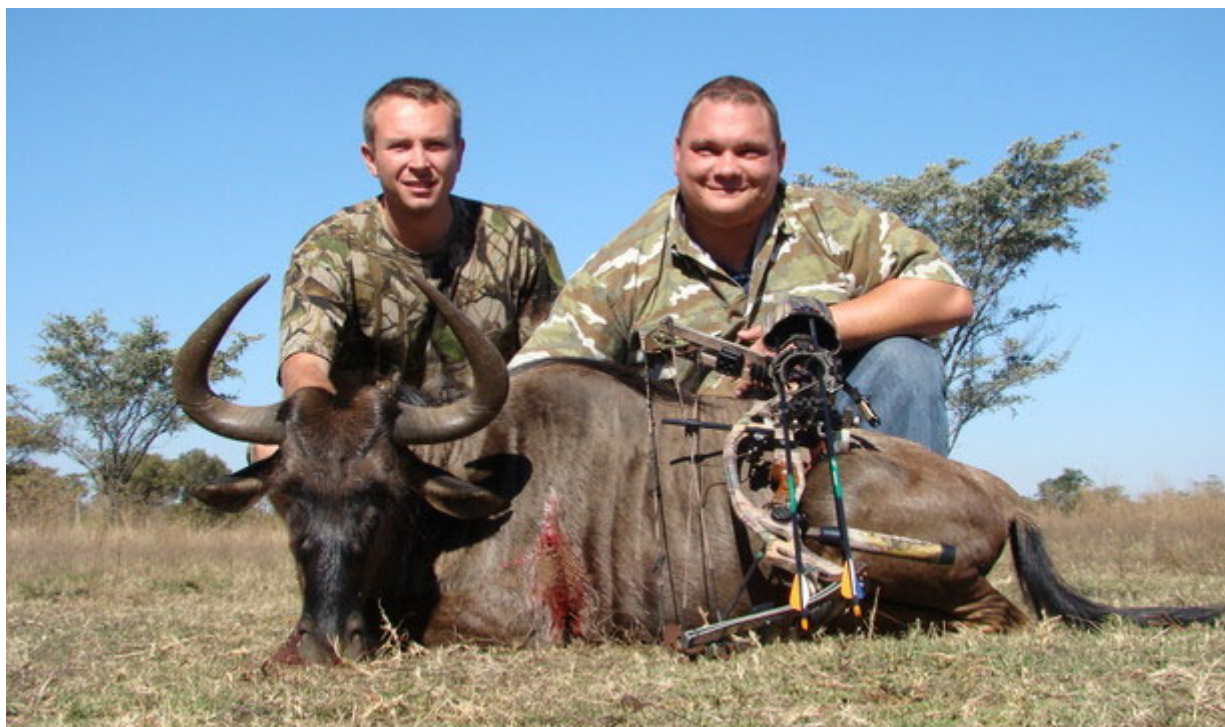
The rest should be adjusted up or down, until the shaft's tear is horizontal.

Then you can adjust the rest left or right, until the shaft's tear is as short as possible. Then you can put on the hunting points and process to walk-back-tuning.

4.1.4   Walk back tuning

This is done with hunting points. The sight is first tuned for 20, 30, 40 and 50Y. Once you are no longer able to increase the precision with the lateral adjustments of the sight, you can start with walk-back-tuning.

Set the sight at 50Y, but stand at 3Y from the butt (keep the sight on 50Y for the whole exercise). Pick a spot and tune the sight until you can place the arrow in a 1cm spot. Then walk back to 50Y, and shoot a grouping. Concentrate only on the vertical / lateral / left-right grouping. If the grouping is to the left of the spot you aimed at, you can move the ARROW REST *slightly* to the right (and *vica versa*). This movement should be only about 0.5mm or 1/32".
Repeat the shots at 3Y and adjust the sight until you hit the 1cm spot again.
Then you walk back and do another grouping at 50Y - adjust the REST until it centers on the target. And so you continue until it shoots true at 3 and 50Y. You should now see the arrows fly straight without any wobble.

Then you can tighten the rest's screws and check it once every 1000 or so shots.

Further Reading: JP de Villiers, **AB&A**, Sep 2008, p52, *"FAQ"*
John Dudley, **AB&A**, Nov 2007, p30, *"Walk-back tuning with broadheads"*
Seppie Celliers, **AB&A**, Nov 2007, p55, *"Stel jagpunte in - maklik"*

4.1.5   Tuning arrows

The last step tuning your setup is looking at the arrows. By this time arrows
with broadheads and fieldpoints should be hitting close to each other. If they
do not, it most probably means that the arrows bend too much as they leave the
bow, i.e. they are under-spined. You can try more stiffer shafts.

If a particular arrow always groups of center, but at a specific spot, it is
most probably the initial bend of the shaft, or a tendency to bend in a
particular direction. Because you have set up everything so far to get the arrow
as straight as possible out of the bow, the way in which the arrow bends is very
sensitive to its imperfections.

If you fletch your own arrows, you can do the following. I put the shaft in the
spine tester, without the weight. Then you rotate it slowly. You will most
probably see the dial going up and down, as it follows the arrow's stiffness. Do
this without the weight used to measure spine, as it will increase the dail's
sensitivity. Then you fletch the arrows all with the natural bend up or down.

Also you should number your arrows. Each arrow groups at a slightly different
spot. You can rotate the nock 120 degrees, and it will move this grouping
around. You can also rotate the nock 180 degrees and try again. Doing this
without having fletched the arrows, at 20Y, if very effective.

In general, bigger broadheads need more tuning attention, as they change the
center of pressure the most (see FOC). If all the tuning does not fix your
grouping, smaller broadheads might help. The alternative is resetting the sight
for broadheads, shorter hunting distances, getting professional help ...

4.1.6   Practicing

Confidence in your ability to hunt is locked up in the aged old saying "practice
makes perfect". SABA simulates hunting conditions on a monthly bases on African
animals in 3D competitions in order to harness our members with knowledge and
confidence of optimally used equipment and arrow trajectory in real hunting
light conditions. "Bokkoors" can't be simulated but can be overcome with the
confidence coming from experience in the hunters shooting ability. Every aspect
of the hunt should be coupled with confidence.

4.1.7   Anchor Points

Archery is almost always a mixture of old and new, and anchor points are a point
in proof. Shooting consistently is only possible if you have a constant anchor
point, and bow grip. In time, with new developments that aid with consistency,
many archers neglect the anchor point and grip. The rationale is of course that
with a peep, who needs an anchor point? In fact, as of date there are even two
products on the market that "eliminates" a peep, and therefore can be seen as to
make a consistent anchor point even less important.

The precise anchor point you use is not that important, although
there are some guidelines. The most important issue is to anchor in exactly
the same way each time.

Some archers anchor below the chin, some against a lucky tooth, some behind the

yaw bone, and so on. I anchor with a knuckle into the back of my ear. Of course, when using a mechanical release, your options are very much defined by the type of release. One interesting variation is to anchor the thumb behind the neck. This provides a very stable support for a very long draw length. Some archers also believe in a third anchor point. This is usually done by touching the tip of the nose to the string. Kisser buttons are also popular with traditional archers, which is a brass nut or even just a small leather strip knotted to the string. The idea is that you put this physical marker on your mouth or lips, on a particular spot each time.

On holding the string with your fingers, there are two schools: the Mediterranean way, and the apache way. The Mediterranean way uses two fingers above and below the arrow, while the apache hold puts just one finger above the arrow. Some people shoot with three fingers below the arrow, and none above.

If course, the innovation of the peep sight have greatly enhanced accuracy even where archers tend to neglect their anchor point. However not everybody likes a peep sight. There are lots of issues around it, for example if it's aligned with the aid of an elastic band or string, whether it is a round hole or a slit, or the size of the peep. But we'll discuss these when we talk about sights.

The one aspect of an anchor point that is usually explained is its function as rear sight of the bow (from there the tendency to neglect it in favour of a peep). However there is another important aspect that is not normally thought of.

If you look at the whole stance of the archer, the anchor point is always above the shoulders. The shoulders are the bases on which your arms are anchoring to not only draw the bow, but to hold it up, and to hold it still. This implies that there is an angle against which the bow pushes against the bow-arm.
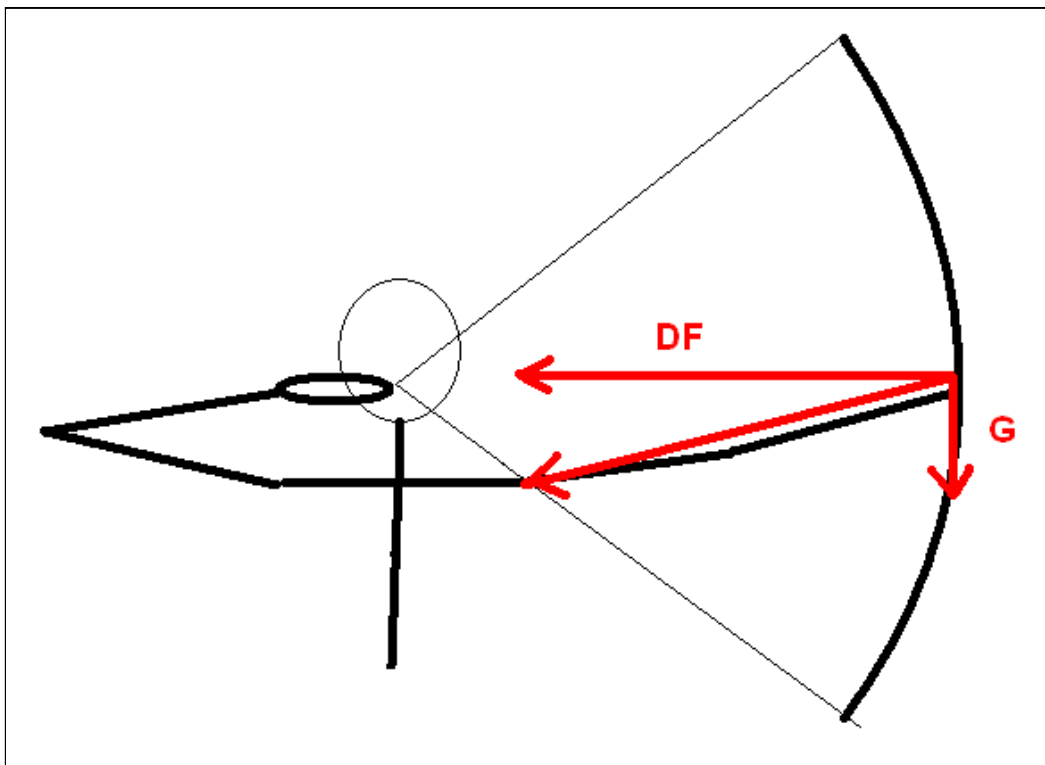
As you can see on this drawing, the string arm is also supplying lift to the bow-arm when it draws the bow. The height of the anchor point above the shoulders determine how much of this pull is used to keep the bow up, vs. drawing the string back.

When you release, the component of the string arm that keeps the bow arm up falls away, and you see a tendency of the bow arm to fall when released during the "surprise shot" (see "Aiming" for a definition of this). So you can see that changing the height of the anchor will put more or less strain on the bow-arm to

keep the bow up. Also when you change the physical weight or the draw weight of the bow, the strain changes.

The best height of anchoring will therefore not just depend on your favourite form, but it will be dependent on the bow that you shoot with, and where it settles into a point of comfortable balance. I often hear, and experience myself, the problem of "my sight is glued to the target just below the spot where I want to shoot, and I cannot seem to lift it that last inch or two". Although this phenomenon can be the result of target panic (see elsewhere), it can just as well be the anchor point that is giving you problems. If you experience this again, try pulling harder at the string, and you will see the bow lifts suddenly. This "below the spot freezing" is not a sign of panic, it is more an indication that you are relaxing your body, as it should be.

The bow is moved up or down not with the bow arm, but with the draw-arm.

4.1.8   Draw length

Determining the correct draw length is important, and very easy. Measure your arm's span from fingertips to finger tips, stretched out to the sides against a wall, and divide this with 2.5. Use this to set the bow's draw length, and then you can fine tune it further with either adjusting the cams, or string length, or even the D-loop length.

When at full draw, your bow arm should be slightly bent, while your shoulders are slightly "open" to the shot, i.e. not parallel with the arrow. If the bow's draw length is too long, your shoulders will "close" the stance, and you will probably straighten and lock your bow arm. This will result in some serious injury as the string hits your forearm... If you frequently experience this, you will soon give up archery! Decreasing the draw length may help to prevent this painful situation.

A too short draw-length will leave your shoulders too open, and put more stain on the shoulders. This will lead to accuracy problems, and your shoulders to tire quickly. The straighter you shoulders and bow arm are, the less strain they take to hold a drawn bow.

The correct draw length therefore keeps things out of the way of the strings, but not too far from the shooting line.

4.1.9   The Grip

The solution is of course that when you do relax your chest muscles, you must pull a bit harder with your back muscles, to get the string-arm's shoulder to rotate further back, and therefore to pull slightly harder - to lift the bow into line again. But after all, the anchor point you use, should be comfortable, and by definition, this will be close to the point of balance. When talking about bow grips, I got the following advice. The top of the handle should lie in the V of the thumb and the hand, and the bottom part should rest against the heel of the hand, between the thumb and the hand muscles. In other words, the top of your hand should be about 40 to 45 degrees turned out, while the bow is vertical.

The reason for this slightly strange hold is simply to keep your arm away from the string. Many archers wear arm guards, for exactly the danger of the string touching the forearm during release. (This can also be a symptom of a too long draw length.) Keeping the wrist turned in that way, the bow arm slightly bent, and with the correct draw length, you should never suffer the wrath of a string. When holding the bow at full draw, the bow hand should be relaxed, and the fingers preferable be open - at least not touching the bow. The idea is to make contact with the bow only on the side of the handle closest to you.

A tight grip usually puts an unnoticed torque on the bow, that pulls

the arrow to the sides during release. With a relaxed hold, only touching on a small part of the handle, this torque is greatly reduced.

There are a few products on the market that promises to eliminate bow torque. These products are usually fastened on the riser, and shows the archer if the riser is torqued. Torque rotates the riser slightly from its natural position in full draw.

One such product contains a small lens and reflective area for light. This device, if properly adjusted, not only shows you torque, but also does the same as a peep in that it fixes your anchor point. A second device uses two parts or pins, which must be aligned for proper sighting. Both of these shows torque as a misalignment. When I just started shooting I built my own "torque indicator". I used a small 5x5mm mirror, adjustable, fixed to the riser. I adjusted the mirror such that I saw the peep reflected in it when looking through it at full draw. This worked very well, but I realized again that to depend on the gadget to fix the problem, which was an inconsistent grip, is not the way to go.

Again, the best grip is the comfortable one, the one you can consistently apply.

4.1.10   Aiming Technique

There is generally two ways to aim, without or with a sight. When shooting without a sight, you have to judge the trajectory of the arrow. This takes extreme levels of practice to achieve. Mostly used by "traditional hunters", which are shooting with longbows and recurves. There are a few archers who have achieved unbelievable accuracy in this way, however, most hunters are more successful using sights. Shooting instinctively does have the advantage of being fast. It is possible to aim and shoot in much less time than it would take using sights. This is a technique to be practiced, and very little else can be said about it.

Most bow hunters these days shoot with sights. Shooting with a sight is not as easy as it would seem at first glance. There are two types of sights on the market, multi-pin sights and single pin sights. With both you need to set the sight up for the distances you expect to hunt at. This should in general be 20, 25, 30, 35 and 40 yards (or meters). (Hunting at further distances is generally not possible or recommended.) But the pros and cons of each will be discussed when we talk about sights in specific.

The biggest problem for all archers is how to keep the sight still, and on target, while shooting. It is in essence what aiming is all about when shooting with a sight. To start with, all muscles under tension trembles. The frequency with which they tremble is a function of the length of the neural feedback loop that controls the tension in the muscle. The physical length of this loop cannot be shortened, since it is built with neurons going from the muscle into the spinal column, and back to the muscle again. However, the speed of the signal, and therefore the time it takes to travel this same distance can be changed.

A good diet is essential, and especially in today's era of zero fats and no cholesterol, people forget that there two fats that we have to eat to stay healthy. These essential fats are abundant in fatty foods, but since we are avoiding these, supplements are necessary. These fats form part of the isolation of neurons, and just like Faraday-screening on electrical wires increases the rate at which information can be sent in them, so a healthy fat layers (called the myelin sheet) on neurons ensure quick response times. With practice, it has indeed been observed, that these layers can increase in thickness, which do increase the transmission rate.
Another source of tremors of muscle is low blood sugar levels. Again, a healthy diet, and some sweet drinks or sweets is useful on a hunting trip. Never shoot when you are already feeling weak or have low sugar tremors.

However, probably the biggest source of unwanted movement is the archer trying to think about the problem.

In exactly the same way that a thin myelin sheet increases reaction time, overriding these reflexes with conscious control, takes way longer. This of course increases the unwanted shaking movement. With practice, an action becomes unconscious. This is indeed what happens, and in becoming unconscious, it also becomes faster. Further practice, and honing of this unconscious skill, will reduce the time for feedback even further. The conclusion to cure the wandering sight syndrome is to relax and not to think about it. Aim like riding a bicycle.

But, even practicing forever will never eliminate all sources of unwanted movement. You will need to breath, and you heart will need to pump. Breathing changes the anchor points of the muscles that is keeping your arms up, so they have to continually change in order to keep your arms still. Again, relaxing and keeping your breathing slow, shallow and rhythmic will help.

Your heartbeat creates a different problem. It causes a pressure change in your arteries, and since your muscles are infused with arteries, it causes them to beat. Relaxing and controlled breathing, will slow down and decrease the intensity of the heartbeat. Of course, if you get "bokkoors", you can experience the exact and extreme effect of this. By the way, there are medication with which can control this. Do NOT USE IT! These drugs pose a serious health risk, not to mention ethical issues.

The actual technique of aiming varies and is mostly a personal thing. It is suggested however to draw the bow slightly higher than the target, after which you can allow the sight pin to sink SLOWLY onto the spot.

Generally however, you will find that you approach the target with the open area of the sight. If the pins are fastened onto the right half of the sight ring, the left side will be open, and you will find yourself approaching the target with the pins generally from right to left. This would suggest the best pin configuration to be hanging from the top of the ring, which sadly is not available. In fact, single pin sights usually have the pin fixed to the bottom of the ring.
There is in fact research being done on the effectiveness of various pin and sight type configurations.
Experimented with various designs.
Also see "target panic" for another angle on aiming.

4.1.11   The Release

One of the most important steps in shooting is of course the release. Target archers have a great advantage over hunters, in that they can employ what's called a "surprise release". In effect, the release is done in such a way that the archer is unable to predict the exact moment the release will occur. This in turn implies that they are not able to "compensate", or pre-empt it, with some muscle action. The idea not that the release should take you by surprise, it merely means that you should not be able to pre-empt the exact moment it will occur.
For hunting, a "surprise" shot is not recommended. Usually the animal presents a shot in a very small time window, and you have to control the exact timing of the release. Wind also plays a factor, and if it blows the bow all over the place, again timing of the release is crucial.
So how do you stop from pre-empting the controlled release? With practice of course. Here are two techniques you can use to practice this. Both should be done standing not further than 10Y from a large field point butt, with of course field points on your arrows. Expect uncontrolled shots, so never do this in your backyard in town. Do this on the farm, with everybody behind you.

Exercise one: The dummy release: Draw the bow with your finger behind the trigger. Leave it there and aim. Now imagine you taking the shot, keeping your finger behind the trigger, pull it back as if you are doing the release. Your bow arm should of course stay perfectly still. Do this two or three times, then do the real release.

Exercise two: The friendly release: Have a trusted friend stand next to you. Draw the bow, aim, and allow your friend to enact the release. In this exercise, your bow arm must NOT stay still. It must be pulled to the side as you release, as you can't compensate for the shot, which is exactly as it should be.

Further Reading: Roy Gaylard, **AB&A**, Apr 2006, p36, *"Instructions for beginners"*

4.1.12   Shooting uphill or downhill

The trajectory of an arrow is actually quite a complex model. The complicating factor is that friction in air is dependent on the square of the velocity of the arrow. It is of course also dependent on the arrow design, its broadhead and fletches, and how it travels. An additional factor is the angle of the fletches. This causes more friction during release, but potentially a straighter flight, endless friction at the last stages of the flight.

However, ignoring most of these factors, except the speed dependancy, does provide useful results. Starting off with friction, it acts like a force (F_r) that decelerates (d) the arrow: d = F_r / m, where m is the weight of the arrow. The again the friction is dependent on the speed squared: $F_r = k.v^2$.

Using the equation $v_{i+1} = v_i + K.v_i^2.dt$, (where the speed at each step is calculated with K and the speed in the previous step, and small time slices) K can be adjusted until the model and the arrow looses the same speed over the first 20Y, to within as accurate as you can measure the arrow's speed. Also note the similarity if this model with calculating penetration depths.

So what is this useful for? The simplest model for shooting angled shots is using the COS-rule. The results from this program are however much more exact. Of course, the result is dependent on the particular arrow, and how fast you shoot it. Here is an example of the output of such a program (this was for an arrow at 260fps):

Angle						
45:	6.5	14.2	21.5	29.1	36.7	44.4
40:	7.5	15.3	23.3	31.4	39.7	47.8
35:	7.7	16.5	25	33.5	42.2	51
30:	8.7	17.2	26.4	35.1	44.2	53.4
22:	9.2	18.6	28	37.6	47.2	56.7
15:	9.4	19.4	29.1	39	48.7	58.7
	10.0	20.0	30.0	40.0	50.0	60.0
-15:	9.9	19.4	28.9	38.3	48	57.4
-22:	9.4	18.6	27.8	36.7	46	55
-30:	8.9	17.5	25.9	34.4	42.9	51.2
-35:	8.4	16.5	24.5	32.4	40.6	48.5
-40:	8	15.3	22.9	30.3	37.9	45.3
-45:	7.5	14.2	21.2	28	34.9	41.7

An exact formula for calculating the compensation for uphill and downhill shots does not exist. However, the following approximation also works well:

The distance you should use to aim with, is the horizontal distance to the target, regardless of whether you are shooting uphill or downhill.

Some rangefinders already calculate this for you. With older ones, you can pick some other object that is directly below or above the animal. What is also important about these shots is the way in which it's done. You should preserve your shooting form when doing so, and not lower or raise your bow arm to make them, but bend at the waist. Draw and anchor the shot as if the target is straight ahead. Then bend in the waist to aim.

degrees		5	10	15	20	25	30	35	40	45
measured	15	15	15	14	14	14	13	12	11	11
distance	20	20	20	19	19	18	17	16	15	14
	25	25	25	24	23	23	22	20	19	18
	30	30	30	29	28	27	26	25	23	21
	35	35	34	34	33	32	30	29	27	25
	40	40	39	39	38	36	35	33	31	28
	45	45	44	43	42	41	39	37	34	32
	50	50	49	48	47	45	43	41	38	35
	55	55	54	53	52	50	48	45	42	39
	60	60	59	58	56	54	52	49	46	42

There is a way in which to compensate using the above concept, without doing any maths in the field. It involves however that you set up a "zero yard pin". It also assumes you are using a multi-pin sight.If not, you can implement the idea on a piece of card bord. This zero yards pin should be set up above the 20Y pin, at about the same distance from it as the 30Y pin is below it. When executing the shot, you first aim using the zero yard pin, holding the bow vertical or straight up. I.e. you ignore the peep and anchor point, and put the 0Y pin on the target, with the arrow exactly horizontal. If the distance measured was say 40Y, look and note very carefully at where the 40Y pin touches the animal/target while doing the aiming on the 0Y pin. Now lift or lower the bow, draw it, anchor, and aim horizontally through the peep at an imaginary target level with yourself.
Now bend in the waist, until you get the target into view again. Put the 0Y pin where it was previously.
Now check on which pin the 40Y spot you mentally marked earlier, falls. For example let us say it is the 30Y pin (it must be less than the measured distance). Now you lift the bow slightly, and aim normally with the 30Y pin, and shoot.

Step 3

Aim using touching point on sight.

0Y pin

Y.CosS

S

Y

20Y pin

Target at 20Y

STEP 2

Cant bow and check where target touching point is on sight.

STEP 1

With pins vertical, where does 20Y touches target?

20Y pin points to here if looking over 0Ypin, holding bow vertical.
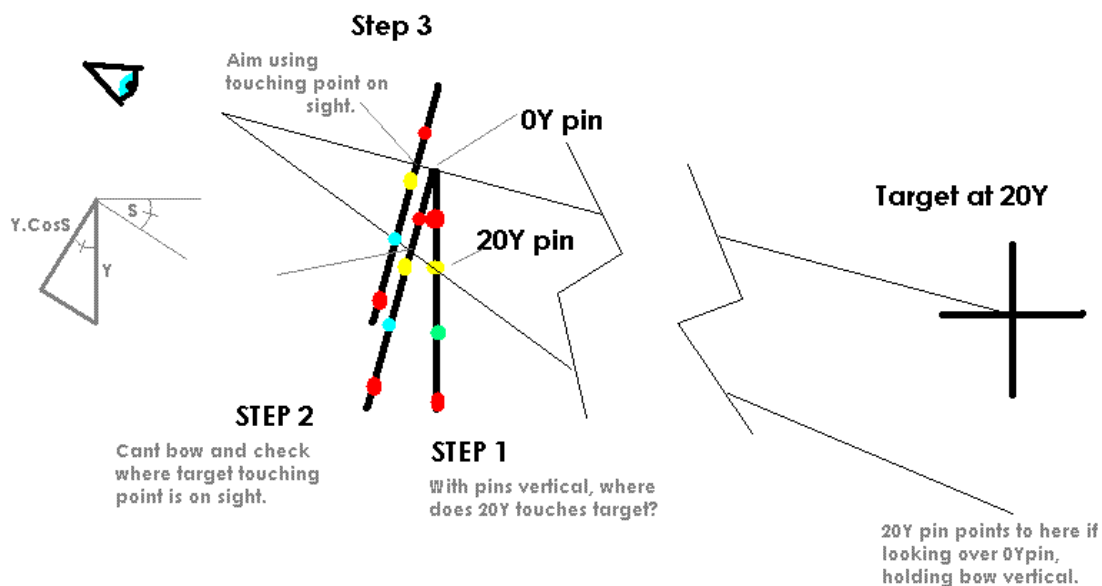
Further Reading: Harry Marx, **AB&A**, Mar 2008, p14, *"Compensating for shooting at a slope"*

4.1.13   Shooting through a gap

Often when you walk and stalk, and even more often if you shoot from cover, you have only a narrow gap to shoot through. This gap may be directly in front of you, but it may be anywhere between the animal and you. Knowing the arrow's trajectory can allow you to miss these obstructions, and shoot a perfect shot.

The obvious starting point is to know that the arrow starts of at about 4 to 6 inches below the line of sight (that which you see when aiming). It then travels upwards, crossing the line of sight, and flies above it for some time, until it hits the target, meeting the line of sight as it comes down. If you have a multi-pin sight, dodging the obstruction is easy.

If your multi-pin sight is set up on 20, 30 and 40 yards (or meters), whichever pin you aim with, the arrow will cross the line of sight over a particular pin, at that pin's distance. For example, if you are aiming at a target at 40Y, the arrow will be at 20Y, where ever the 20Y pin is aiming at. At 30Y, it will be at the point the 30Y pin is aiming at.

Here is an illustration (NOT to scale) of this:

For an arrow traveling 250 fps:

red = 20Y pin
yellow=30Y pin
green=40Y pin

A = about 3.6Y
B = about 4.5Y
C = about 5.6Y

D = exactly 20Y
E = exactly 30Y
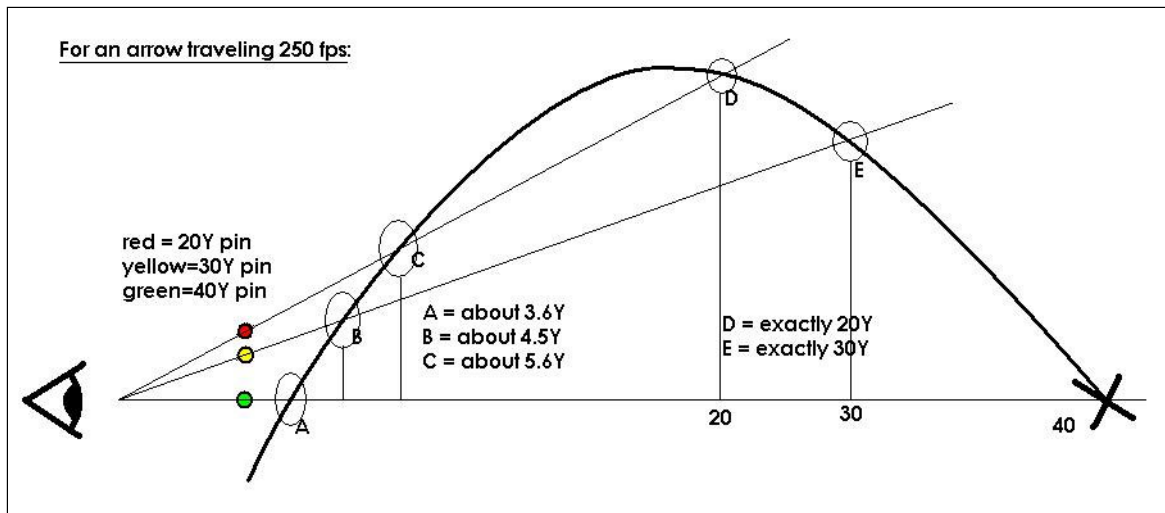
The arrow passes through the loops at various distances. What is very useful to note is that if you moved loop E, such that the arrow falls through it on the 30Y pin's line of sight, that loop will be at 30Y. In other words, if the loop (or gap) is at 20Y (as is loop D), the arrow will fall through it if the 20Y pin's line of sight is on it!

The points at which the arrow passes the line of sight going up, is not that straight forward. Firstly the arrow's speed has an influence on the exact distance. However, you would be very close if you considered these distance to vary from 3 to 6 yards (or meters), for the 50 to 20Y pins. Which again means that if you aim for a buck at 40Y, the line of sight for the 20Y pin must be clear of obstructions at 6 and 20Y. The 30Y pin must be clear at 4.5Y and 30Y. And the 40Y pin must be clear at 3 and 40Y.

Now you may wonder where in the trajectory is the arrow's highest point, and how high is it. It will be very close to halfway between the target and you, and very close to the line of sight for the pin position that corresponds to the halfway mark. If the target is at 40Y, it will reach its apex at 20Y (half the distance), at the same height as a loop at 20Y through which the 20Y pin's line of sight goes, while aiming at 40Y.

Now if you do NOT have a multi-pin sight, well... all things comes with its pros and cons. You simply can't do this. However, again you could make a cardboard drawing of a multi-pin sight and use that. Shoot an arrow low into the butt at 30Y. Then walk forward to 20Y, aim at the arrow with the 30Y pin, and shoot a 2nd arrow. Walk back to 30Y, and mark the vertical distance between the arrows on the card (starting at the top of the card) as 20Y (upper arrow) and 30Y (lower arrow). Hold the card at arm's length. Now do the same for 30Y and 40Y, marking 40Y below the 30Y mark made previously.

4.1.14   Target Panic

Every archer and hunter experiences target panic at least once. It can take a number of different forms: the inability to release the arrow (freezing), the inability to move the sight on to the target, or snap shooting - releasing the arrow the instance the sight passes the target.

All of these forms are the result of a single psychological (mental) reason - the fear to miss the target. Missing the target can mean just loosing the arrow, or at worst wounding the animal. This fear manifests in a mental block that either freezes up part of the action, or causes a premature release.

There are three possible treatments for it. I refrain from calling them cures, since target panic is not a disease, but a state of mind, and frequently resurfaces.
1) The first treatment requires you to lower the bow's draw weight, or shoot with a lower draw weight bow. This eases the tension in your body at full draw, making it easier to aim, and as such lowers the possibility of missing. Once you

are again comfortable, you can slowly increase the bow's draw weight again.
2) The second treatment involves a change in form, usually by changing the type
of release used. "Back tension" releases are usually offered as the cure, but
I'm skeptical, and in any case they are not recommended for hunting.
For myself I found a redesign of the whole trigger assembly, inverting the
trigger action from being pulled to being pushed, helped to a large degree. In
general, if you flinch - i.e. you pre-empt a shot that did not take place, you
instinctively closes the trigger hand. This of course forces the release, as
your finger is usually on the trigger. If however you need to push the trigger
forward to release the arrow, closing your hand during the flinch moves it away
from the trigger, and this knowledge greatly reduces mental tension (and reduces
the danger of a uncontrolled fire). Sadly again, this type of release is very
scarce.

3) The most effective treatment is however to remove all targets
from the butt, and to shoot at it from a ridiculously close distance, say 5Y.
In such a position you simply have no fear of missing the target or the butt.
Shoot like this until you are comfortable (bored), and can perform both the
exercises for good release, without flinching, or even needing to suppress a
flinch. Then you can add a target, still at 5Y, and go at it again. The next
progression is to repeat this process at 10Y, then 15, etc.

Shooting at 5Y with your eyes closed is also suggested frequently. I found this
generally to increase anxiety, and do not suggest it. You will probably need to
return to these treatments in time. I found it useful to include these
activities as part of my normal exercise routine.

If you are shooting for a long time, a different problems starts to rear its
head. You start to shoot more "instinctively" (without thinking). This sometimes
causes you to "lose control" of your trigger finger.As the pin approaches the
target, the shot simply goes off - and you never instructed your finger to pull.
You can easily measure the degree to which you are already suffering from this.
When aiming next time, put the pin on the target, touch the trigger, but do not
pull it. If you can do this, you are still "in control". If you cannot, well,
you have a problem. The feeling is similar to the urge you get to close your
eyes when someone threw sand in them. It is almost unstoppable - the shot MUST
be done... I know, since I suffer from this. But luckily there is a good
treatment for this as well. You see if some action is being performed
unconsciously due to repetition, you only need to change the action and it will
"bounce" back into consciousness, or conscious control. The treatment in this
case is to change the finger you pull the trigger with. Doing this change often
keeps the process from falling into unconsciousness.

Also see the exercises under The Release.

Further Reading: John Dudley, **AB&A**, Jan 2008, p15, *"Curing Buck
Fever and Target Panic"*

4.1.15   Arrow Care

Make sure you arrows are clean. When shooting into 3D targets, often some of the
material sticks to the arrow. This should be removed before you can shoot with
the arrow again. This material not only make the arrow lie incorrectly on the
rest, but can also bump it in any direction as it is released. You can rub the
shafts in hard, old soap to protect them against it.

Frequently inspect your arrows. Bend the arrow in all directions and check for
cracks and listen for cracking. Aluminum arrows of course bends easy, and dents
if it hits against other arrows during practice. The bends and dents hardens the
aluminum, and makes them prone to cracking. It is a good idea to heat the shaft

at the spot of the dent with a candle or cigarette lighter. Carbon fiber and fiber glass arrows of course do not dent, they break. Never shoot cracked arrows.

The most frequent issue with arrows is however the nocks. They take the most strain during release, and if they break during release can cause serious damage to your bow, for practical purposes causing a dry fire.

Also check the fletching frequently. Needless to say, loose or cut fletching affects arrow flights.

Further Reading: Seppie Celliers, **AB&A**, May 2008, p59, *"Presteer jou pyle?"*
Seppie Celliers, **AB&A**, Feb 2008, p56, *"Hoe om pyle te kies en te 'tune'"*
Schalk van der Merwe, **AB&A**, Mar 2008, p51, *"Vlieg jou pyle reguit?"*
Mark Slatter, **AB&A**, Sep 2009, p19, *"Assembling Arrows for maximum penetration"*
John Dudley, **AB&A**, May 2008, p30, *"Pre-season arrow building"*

4.2   Preparing for the hunt (overview)

Your equipment must be in top working order and you must know which animal category can be hunted with the bow equipment as a whole. Prepare thoroughly and check each component for optimal mechanical operation. When arriving at the game farm, be thoroughly briefed and get the farm's rules and regulations together with a price list of animals that may or may not be hunted. Always have a knife and a good wire cutter in your daypack to remove snares set by poachers.

Further Reading: Herman Brand, **AB&A**, May 2008, p56, *"Wenke vir daardie eerste keer"*
Johan Steenkamp, **AB&A**, Aug 2007, p25, *"My First Hunt"*
Engee Potgieter, **AB&A**, May 2007, p27, *"Pre-season preperation"*
Herman Brand, **AB&A**, Feb 2008, p47, *"Wat maak 'n bok dood?"*
Johannes Schabort, **AB&A**, Apr 2008, p56, *"Hoe goed moet jy klan skiet?"*
Dieter Noli, **AB&A**, Mar 2008, p71, *"Extreme Bowhunting"*

4.2.1   "Walk and Stalk"

Further Reading: JC Botha, **AB&A**, May 2008, p68, *"The art of Walk and Stalk"*
Johannes Schabort, **AB&A**, Oct 2007, p30 , *"Getting into bow range"*
Cleve Cheney, **AB&A**, Aug 2007, p14, *"Bushcraft: Walk and Stalk"*
Engee Potgieter, **AB&A**, Jun 2008, p58, *"Stadig deur die bosse"*

4.2.2   Hunting from hides

Further Reading: Herman Brand, **AB&A**, Apr 2007, p31, *"Jag uit 'n Skuiling"*
Pieter Oberholzer, **AB&A**, Sep 2007, p49, *"Die Onderskatter Boonstoel"*

4.3   Hunting Fish

Further Reading: Herman Brand, **AB%A**, Oct 2006, p50, *"Visskietseisoen is hier"*
Cleve Cheney, **AB%A**, Dec 2006, p8, *"Bowhunting Fish"*
Herman Brand, **AB&A**, Dec 2006, p50, *"Voorreg om vis te skiet"*

4.4   Hunting Birds

Further Reading: Cleve Cheney, **AB&A**, Jun 2006, p8, *"Hunting Waterfowl"*
Engee Potgieter, **AB&A**, Jun 2006, p23, *"Hunting Waterfowl with bow and arrow"*
Engee Potgieter, **AB&A**, Aug 2007, p31, *"The ABC of bowhunting for birds"*

4.5   A Primer on Shot Placement

The animal always comes FIRST. A picture of you and a successfully bow hunted animal, capture what this book is all about. With the hunter in the background and the hunted quarry in front, the picture advocates to the world the essence of the skill of bow hunting in its truest form. The world looking at your picture sees the animal in the foreground FIRST and the hunter in the background.
Shooting groupings in your back yard, practicing simulated hunts at SABA's 3D competitions and in-depth equipment knowledge, harness your confidence in your ability the moment the animal are spotted.

- Study the animal and its behaviour. Wind direction, animal body position, age, gender, young, open shot and Game Farm rules are some critical aspects of this study.
- Visualize the shot where the arrow will break the skin in the vital area by picking a reference spot on the animal's hide.
- Know the exact distance to the quarry. No matter how good you can GUESS distance, make use of a range finder and make double sure. This will harness your confidence and be a building block to eliminate or ease "Bokkoors".
- Follow your practiced archery routine and be ready to be tested at the highest level of the sport, namely bow hunting. Tip: Remember to breath.

It's not the bow that kills the animal, and not even the arrow, it's the hunting point. The blades must be as sharp as you can get them. Furthermore, for any shots all the major bones must be avoided. So if the animal is standing nicely quartered, shooting for the heart is considered a risky shot, since almost half of it may be obscured by the forward leg. So it depends very much on how far you are from the animal, and how accurate you can shoot. In general, it is good hunting practice to shoot a safe shot. If you draw a triangle on the leg bones, and the largest circle inside this, the safest shot is for or just behind the centre of this circle. If the animal's nearest front leg is forward of the other front leg, as if he last stepped with it, the heart is of course opened for a clean shot.

Most printed targets on sale are for rifle hunters. Usually they show the position of the lungs, heart, neck and brain.This is not particular applicable to bow hunting. For bow hunting practice only the heart and lungs are of real importance.
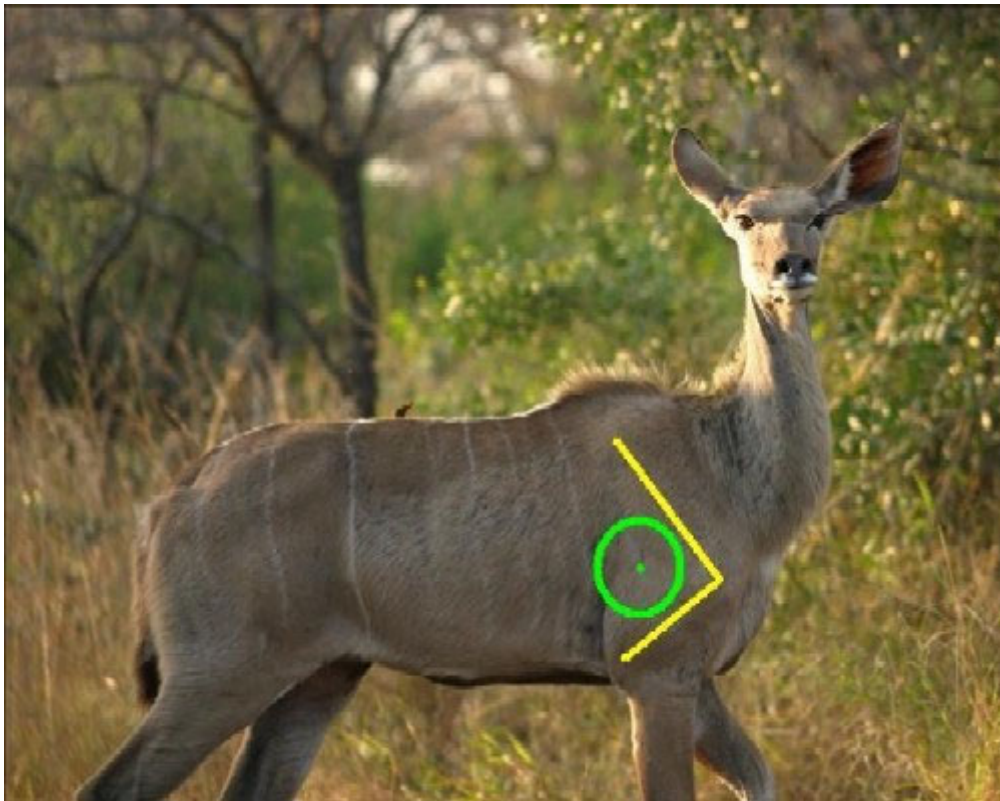
The moment the animal turns away from you, or stand "quartering away", you have to adjust the aiming point. Remember that the arrow should pass ideally through the centre of the chest. Therefore, if the two legs are next to each other, like in the picture of the impala below, the centre of the chest lies on a vertical right in the middle of the two legs. Although such a shot has less chance of hitting a major leg bone, it does hit the rib bones at an angle, making a deflection more possible. It is therefore also in the light of some mechanical hunting points' tendency to deflect, that such a shot with mechanicals should be considered very carefully. Rather use a point with a "cut on contact" point. Shooting for the heart is more feasible from a slight quartering away position.

The more the animal turns away from you, the smaller the target window becomes and eventually closes.
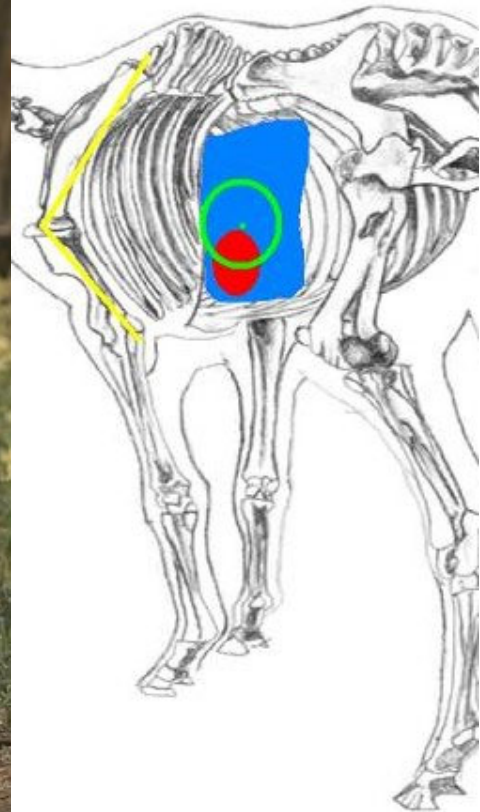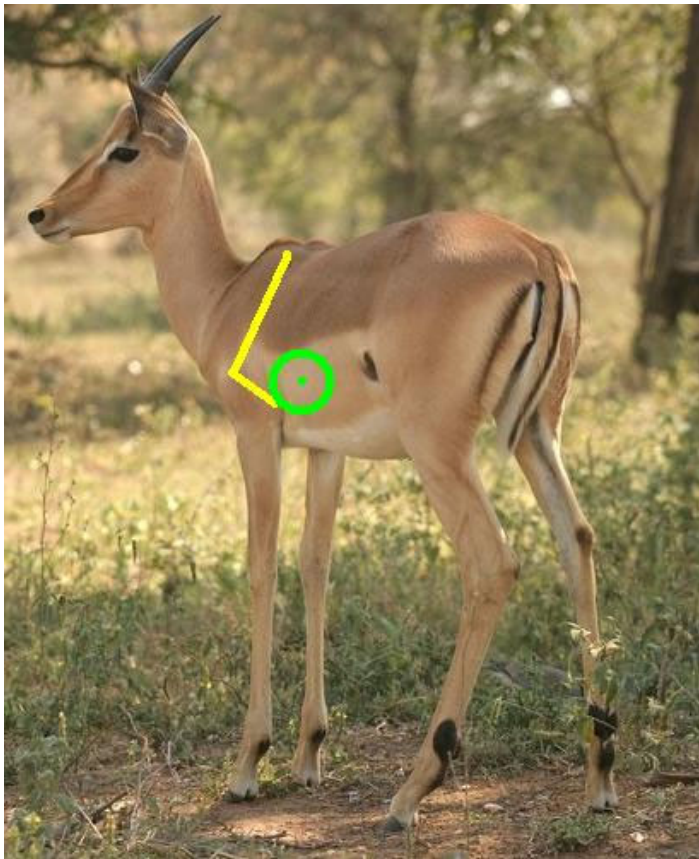
In the above example, many hunters advocate to shoot for the furthest leg, which
is still acceptable. It is slightly risky in that if you pull to the right, you
may only hit one lung.

When animals have their nearest front leg in front of the vitals, as with this
springbuck, any shot is risky. You may have the power to break the leg bone, but
it may also cause a deflection of the arrow. This in turn will effect
penetration severely, and may end up with a very long tracking exercise.

In the same way a quartering forward shot is considered very risky.
The arrow will have to find its way among the major leg bones. Also, if the
animal starts to move due to the sound of the bow or arrow, as it crouches
to "load" its legs for the jump, these heavy bones close the whole shot
window.

Full frontal shots are possible. It is however considered very
controversial,because the shot window to the heart is very small. You cannot
really target the lung from the front, and in any case you would hit only one
lung if you do at all.
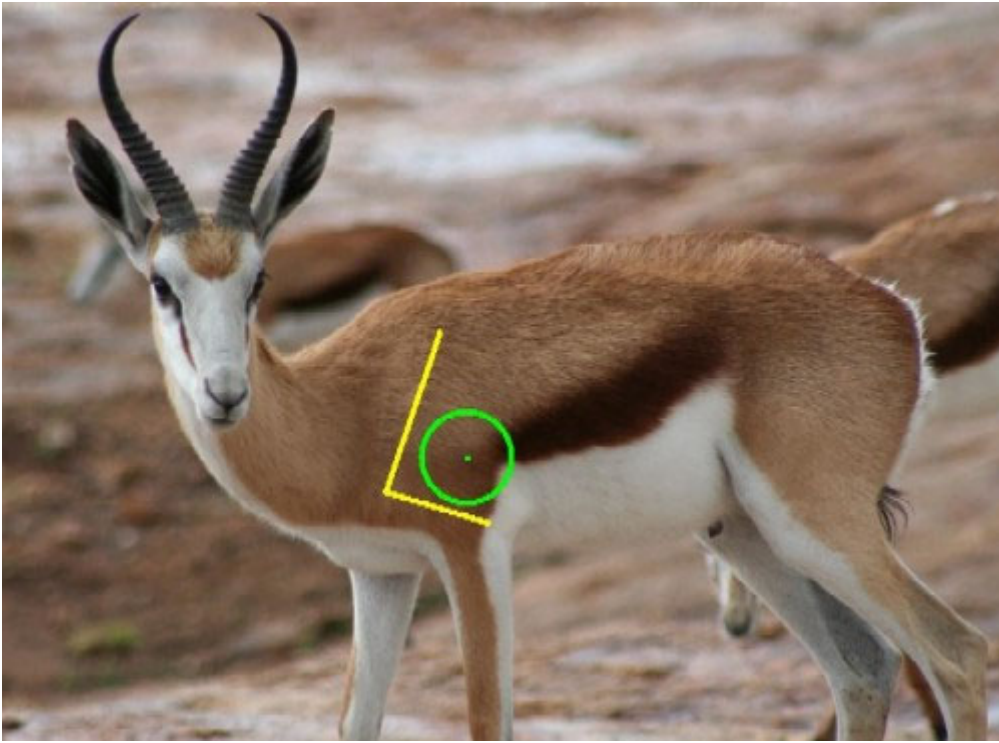
🪶This would be a cause for a long trek. The smallness of the full frontal shot is due to the breastbone and leg boneson either side of the window, and the neck on the upper side thereof. The vertebrates of the neck is extremely low where it enters the chest, and with a rifle, if you shoot from the front below the animal's mouth, you are most probably going to destroy the lower neck. But with a bow, you have to go for the heart and aorta here. You probably need to be able to shoot a grouping of 1" at the distance of the animal (all categories), before even attempting this. And there is simply no margin for error, so do it only at a very close

distance.

The animal is also looking at you, already making it risky. And if the animals should jump at all at the bow sound, remember the small shot window, you missed it. Therefore it is not recommended at all.

This kudu also illustrate another source for errors in shot placement, its chest mane. This is a serious source for wrongly estimating the chest too low. Rather use the elbow or the shoulder joint as reference, since the heart lies horizontally between these two.

It is important to remember that even though you can shoot far more accurate than the animal's position and vital area dictate is needed, any movement of the animal, and the shot is at least marginal, at most a wound. Recommended distance limitations are defined by the hunter's accuracy, the animal's vital area size, AND the probability of the animal to move. The further the shot taken, the higher the chance the animal moves, the bigger the effect of its movement, and the further it will move before the arrow gets there.

Tree stand shots (or elevated hides) present the hunter with a new set of shot placement problems. Normally the animal is closer to you than during a walk-and-stalk, and it's usually at an acute angle. This angle implies you need to adjust the distance used to aim with, and you need to change the spot where you aim. For a very important slant on shotplacement, read "Shooting Distances based on reaction time" again...

The best practice for distance measurement at tree stands is to measure first a number of marker objects, from the base of the tree stand, while on the ground. This will give you the horizontal distances. Once you are in the tree stand you use these markers to estimate distance.

You also need to lift the spot you aim at slightly, depending on the angle. You should be aiming for the top of the heart, which is basically just below the centre of the chest. The spot you aim at now can even be high up on the rump, passing through the centre, and exiting at the bottom of the chest.It is suggested that you do not aim for the spine, and therefore always aim for the arrow to miss it to either side. Also see "Shooting uphill or downhill", and the effect speed has on accuracy.

4.5.1   ...from the inside

Here is an interesting perspective on vital area diameters. These animals were frozen and cut into half. This provides us with the position and size if vitals organs. Just as animals differ on the outside, the precise position and form of the internal organs also shows some variation.
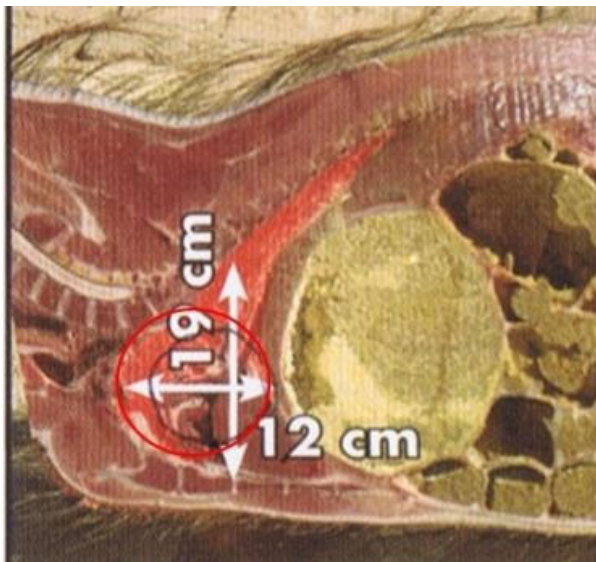
Although warthogs are placed into category 2 due to their toughness, they must definitely be treated as category 1 for the purpose of accuracy.
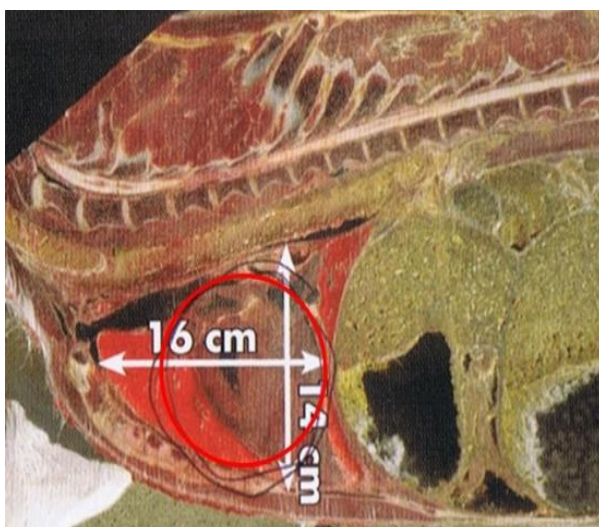
Here we look at a category 1 animal, a Springbuck. Its vital area is about 5.5" at its narrowest.
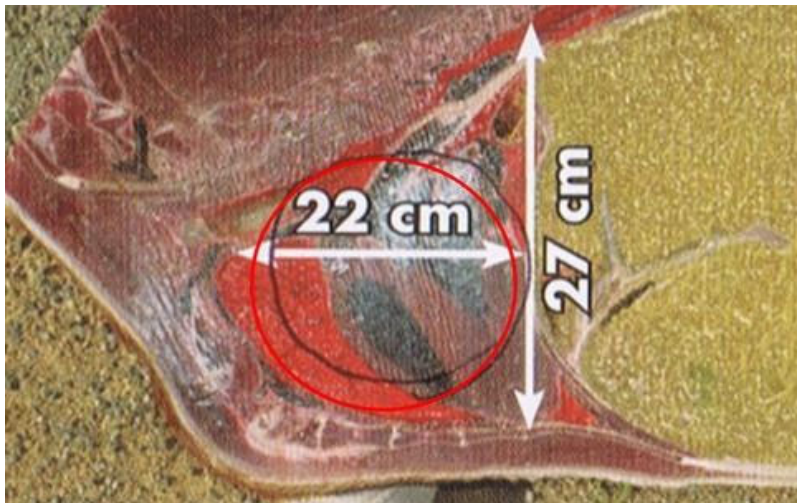
Blesbuck, with a vital area diameter of 8.5"
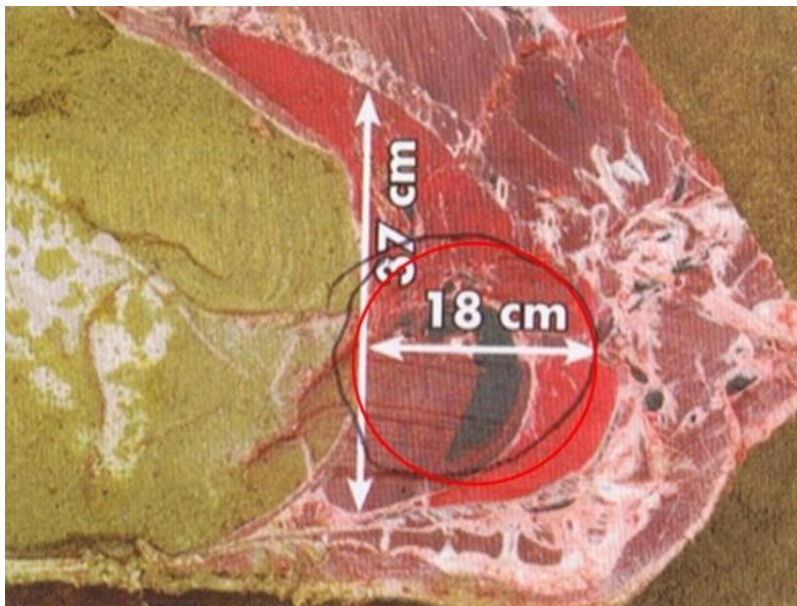
Blue wildebeest, with a surprising 7". This is smaller than expected.
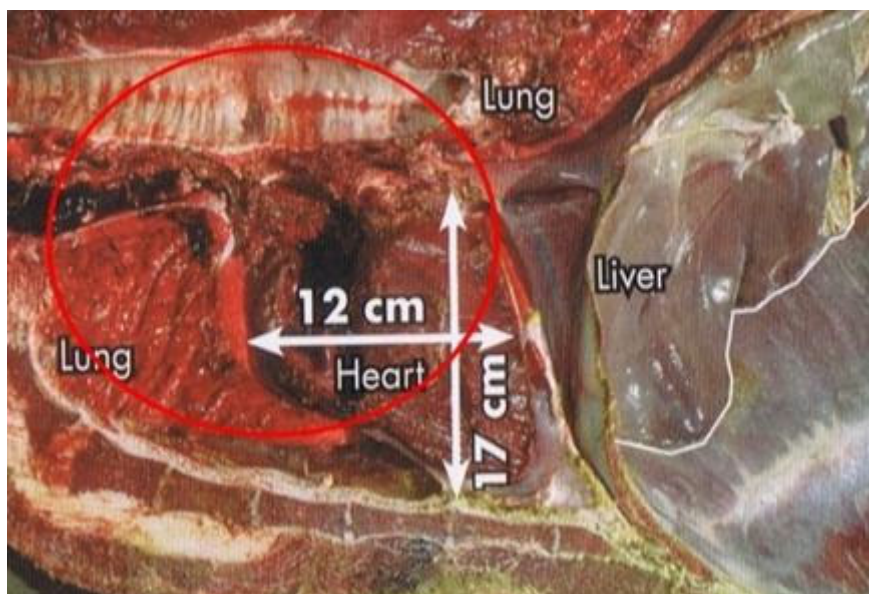
And here we have a kudu, also about 7".

Although these are interesting studies, one photo does not represent a specie.
We do not know the age of these animals, nor does the exact cut through them
looks like it cut throught the middle.
Of course, you can't cut the animal right through the middel and cut any
lungs...
Intersting, but not that imformative.

Further Reading: Cleve Cheney, **AB&A**, Mar 2008, p8, *"In the Zone"*
Willie Oosthuizen, **AB&A**, Jul 2007, p17, *"Shot placement for trophy purposes"*
David Guthrie, **AB&A**, Jan 2007, p10, *"The G-Shot"*

4.5.2   Accuracy

The first thing about accuracy is arrow weight. You can ask the question, how close do my arrows need to be matched for weight, to shoot within 0.5 inches of each other? Here is a simple equation with which to calculate this:

$$dW = 2.(m+100).H.V^2/(S^2 g).$$

m is the arrow's mass, H the acceptable drop, V the speed, and S the distance. However, the answer is mostly dependent on how far you plan to shoot. If you shoot 20Y, your arrows must be within 18gr. If you shoot at 50Y, they must be within 3gr. Olympic archers shooting at 120m must have arrows that is within 0.5 gr.

The bigger a broadhead, the more it is likely to plain, or steer the arrow, and thereby making it unstable. Broadheads shoots larger groupings than field points. This is why SABA requires accuracy assessment and 3D competitions to be done with broadheads. Many broadheads have cutouts in the blades. These help to reduce the surface area of the blade which contributes to less plaining, and less penetration friction.

In general, when increasing the blade area, fletching area should also be increased. Some hunters suggest to use even 4x 5" fletches on 4 bladed broadhead. Of course, the better the bow is tuned, i.e. the straighter the arrow leaves the bow, and the quicker it stabilizes, the better the grouping you will get with broadheads. Lighter arrows also stabilize more quickly than heavier ones.

Bad groupings with a particular broadhead usually reflect on the broadhead and arrow stability. More fletches may help, and increasing the angle of the fletching may help. Changing the spine or FOC may also help.

If you find that the grouping does not change, but the broadhead shoots consistently off target,the problem can usually be corrected with bow tuning.

Further Reading: Sampie Stofberg, **AB&A**, Mar 2009, p42, *"Wanneer om te skiet"*
Herman Brand, **AB&A**, Nov 2008, p57, *"Stop en Verbeter"*
Sampie Stoffberg, **AB&A**, Nov 2008, p57, *"Jaagskote in die Jagveld"*
Seppie Celliers, **AB&A**, Mar 2008, p54, *"Maklike oefen tegnieke om gou beter te skiet"*
John Dudley, **AB&A**, Jan 2008, p15, *"Curing buck fever and target panic"*
Seppie Celliers, **AB&A**, Oct 2006, p51, *"Hoe kan ek beter skiet? (Part 1)"*
Seppie Celliers, **AB&A**, Nov 2006, p50, *"Hoe kan ek beter skiet? (Part 2)"*
Seppie Celliers, **AB&A**, Dec 2006, p49, *"Hoe kan ek beter skiet? (Part 3)"*
Johan Smit, **AB&A**, May 2007, p30, *"Oorkom plukskiet"*
John Dudley, **AB&A**, Sep 2007, p38, *"Maximizing you hunting accuracy"*

John Dudley, **AB&A**, Oct 2007, p25, *"Shooting Accurate Constantly"*

4.5.3   Estimating Ranges

Although it is highly recommended to use a rangefinder, the following techniques
may come in handy if the battery goes down, or the device fails... Always bear
in mind that you can for any technique simply divide the distance into two, and
estimate the nearest half's. Double it then for the whole distance.

4.5.3.1   Ground Distance estimation

Learn to estimate a particular distance, say 10y, on the ground, towards the
target. The technique is then simply to count how many times it fits into the
total distance. You can also estimate multiples of 10 and then 20 yards, etc.,
and get the average.

Disadvantages:
·   The terrain must be straight (not necessarily level).
·   Bushes and lighting will influence the estimation.
·   You need a clear ground view up to the target.
Advantages
·   Very simple and intuitive

4.5.3.2   Angle Cards

These cards are marked with the apparent height of 1m at various distance
intervals, when the card is viewed at a particular distance.

Reading the marking corresponding to the object's apparent height, and
multiplying it with the mark value and actual object height, gives the desired
estimate.

A butt at 1.2m high, viewed to correspond with x20, holding the card at 75cm, is
1.2m x 20 (24m) away.

To simplify the maths a bit, you can estimate the distance of an imagined 1m or
yard stick, standing at the target. The factor on the card then corresponds
directly with the distance.

If the height is unknown, this procedure is only as accurate as your estimation
of the object's height, or an estimation of the height of 1m, at that distance.

Of course, the markings get closer to each other the further you go, and the
system becomes less accurate. For angle cards to work you need to either know
how high an object
at the target (or the target itself) is, or you have to be able to estimate the
its height.

Disadvantages
·   Accuracy beyond 40m is difficult
·   Must know or estimate height or width of target
·   Less intuitive

Advantages
·   Ground towards target can be uneven or even hidden
·   Cover and lighting has little influence

4.5.3.3   Using your Thumb

This technique inverts the "angle cards" idea. Instead of comparing the apparent
height with various pre-marked heights, we use the number of times   a

known/estimated distance at the target's position, fits into a single pre-marked distance.

Your thumb should be exactly 1 inch wide. Well mine is. The idea is that if you hold it at arm's length, 75cm, or 30 inches. You then take the estimated/known height of the object, multiply it with the number of times it fits underneath your thumb and multiply that with 30.

For example, if a butt is 4 feet high, and two fits underneath you thumb (arm straight), then the distance to it is 4feet x2 times x30 = 240 feet (80 yards). Working directly with yards, since 1 yard = 3 feet, 4x2x10=80 is easier. You could also imagine a meter or yardstick at the same distance: it would fit 2.6 times underneath your thumb: 2.6times x30=80 yards.

Disadvantages
· Must know or estimate height or width of target
· Can involve some mathematics

Advantages
· Ground towards target can be uneven or even hidden
· Cover and lighting has little influence
· Moderate accurate at distance

4.5.3.4   Using a Ruler

Basically the same technique as the thumb idea above, but with the ruler you can impress more suckers, wink-wink.

Take a 10" rule in your right hand. Put the end against your forehead, so as to measure a hand position 10" in front of your eyes. Turn the rule vertical, keeping your hands level and at 10" from your eyes.
Use your left thumb, or other fingers an any way, to measure 1 inch vertically, from the zero. Hold this 1" vertically, right next to the rule, with it's base at 0".
Now tilt the rule forward towards the target, still keeping it 10" from your eyes, and still keeping a 1" finger mark vertically above the zero. Tilt the rule forwards until it's 1" measurement is in line with a known/estimated height at the target. Now read how far your left hand's finger's 1" (still vertical) mark projects onto the ruler, multiply by 10, and then the height of the object you sighted on (an imaginary yardstick can help again). You could of course use anything with at least 10" marked on it (an arrow comes to mind).

Note, the rule is only there to measure 10", 1" and how many times 1 yd (or a known size) at the target fits into the 1". So if any rules forbid the use of a ruler (to "measure" the distance, ha, ha) then all you really need is a 10" marker (your thumb is 1" thick, and you can estimate how many times your thumb covers it).

Advantages
· More accurate than estimating number of times target is covered by thumb
Disadvantages
· carrying a ruler
· a bit complicated

4.5.3.5   Measured apparent size at 10m or 10y

Another adaptation to the above technique is possible when shooting 2D targets, since they are printed on the same size paper! Walk up to 10yd away from the target, and hold up your bow at shooting length. The target will fill a certain width and height inside the sight, or on the riser. Make a mental note thereof. Now walk back to 20 yd. Aim again at the target. You will now see that exactly 2 targets fits into this gap.
At 30 yd, you'll be able to fit 3 targets therein. And so on. When hunting, you could use the average height of the animal as a point of reference.

This technique requires that you measure the width, and later use it, at the same distance from your eyes. But since the specific distance is not relevant, your individualized arm's length would do nicely.

Advantages
·   Very accurate, even to 50m or yards.
·   Using the width can neutralize uphill/downhill distance estimation errors
·   Very easy to use
Disadvantages
·   You have to measure the target's width at 10m(y) before using it

4.5.3.6   Known size / 100

There are two variations of this technique. They are very similar to the previous ones, but with slightly different accents, and can come in handy to cross check each other. These techniques also start with a known or estimated target size. But instead of using a fixed width a particular distance, use 1/100 of the target's size.

The two variations involve using the "mask" at either a fixed distance from the eyes and counting how many times the target can fit underneath it, or moving the mask until exactly one target fits underneath it.

Let's take the fixed distance first. Say a target/animal is 1.2m high. Make a mask of 1,2 cm, which is the same as 1.2m/100. At a fixed distance of 10cm from your eyes, you can count the number of times the target fits underneath the mask (in the gap). Let's say it's about 1.5 times. Multiply this with 10, and you know the target is at 15m.
If you knew the size of the target in inches, a mask of 1/100 thereof must be place at 3.6" from your eyes, to give after x10, an answer in yards.

The second version of this technique is a bit more intuitive and easy.
Again start with a mask or gap that is 1/100'th the size of the target. 1m would translate to 1 cm.
But now you place it at a distance such that exactly 1 target fits under/inside the mask/gap. Say this is 25cm (measured or estimated). The target is then 25m away.

For this technique, you could translate a target size of m to cm, or yards to inches.
The only problem with yards to inches is that you may need to hold the mask at 40" for a target that is 40y away.

Disadvantages
·   More complex
·   You need a ruler - more equipment
·   else, you need to be accurate in estimating small distances close up.
·   Need to know or estimate the target's size
Advantages
·   Fair accuracy at bigger (40 to 50y) distances
·   Don't need to measure the target sizes at 10m/y beforehand.

4.5.3.7   Parallax

This is an easy technique. Take a pencil, or even a sight's pin, or field point. Hold this at arm's length right in front of you (about 65 cm). Now look with both eyes, at the target.
Estimate the distance on the ground, at the target, that separates the two images formed by your two eyes.
Lets say it's 2y. For an average eye width of 65 mm, and a pin at 65cm, this factor calculates to 10. So the distance is 10x2 yards.
If the distance on the ground is becoming 4 to 5 yards, it becomes difficult, as you may not be able to see such a stretch at the target. For this you can use two pins, and arrange them to see 4 evenly spaced images when looking at the target. Estimate the distance the centre two projects to at the target, and multiply with 20.

Advantages
·   Only one estimation is done, albeit at a distance
·   Quick and easy
Disadvantages
·   You have to see some ground at the target's feet
·   Estimations at distances influenced by lot of factors.

Many of these techniques require you to estimate a distance at the target, or close to you. The ones that are close to you will be more accurate. If you need to estimate more than one distance for a technique to work, it of course becomes less accurate.

All things considered, I opt for knowing the apparent size at arm's length, for the target standing 10 yards away. The number of times it fits into the gap x10 is an easy/accurate estimate.

Be careful of uphill and downhill estimations. If you use techniques dependent on target height, you are doomed to getan estimate that is too far. Instead, consider using target widths to cancel elevations. Just tilt the whole procedure on its side.
Widths are totally unaffected by up or downhill shooting! On the other hand, if a target width is used, and it stands at an angle towards you, it will also create problems.
Of course, shooting up or downhill comes with its own problems...

4.6   Camouflage

Camouflage for bowhunters plays an important role for the walk-and-stalk, and ambush bowhunter (less so for using hides). This hunter needs to get very close to animals without alerting them to his/her presence. For effective camouflage the hunter needs to take various aspects into account: movement, shadows, silhouettes, shape, surface, symmetry, size, situation, sound, and smell.
The biggest problem with camouflage is the better you do it, the more limiting it becomes. The more you blend in with bush, the more you stand out in grass, etc. Even camouflage for a non-moving (ambush/hiding) hunter and a moving hunter (walk and stalk) has opposite goals.

Any **movement** is very easily seen by all animals.When moving in the field, do it as slow as possible. When very close to your target, try to move only parts of your body at a time. It is of such importance that the lack of any movement

becomes an ambush - which is so effective that some hunters feel it's not ethical! The best pattern that hides movement is no pattern at all. A single natural colour or a large low contrast pattern with blurred edges works better for a moving hunter. Smaller sharp edged, high contrast patterns work best for an ambush hunter.

The role of **shadows** is usually underestimated. All colours in shadows become black. Your best and most expensive colour patterns all become dark grey if you are sitting inside a shadow. If the sun is to your back, your front is in shadow, and loses its colour. Likewise if it shines on your front, the camouflage pattern is most prominent.
Shadows work in concert with silhouettes. You should look at the background of where you are, it is either lit or in shadow. If you are not similarly lightened, you stand out as a silhouette, and any movement is easily seen.

The **silhouette** defines your outline, or shape. Another aim of camouflage should be to break the hunter's shape. The use of high contrast on edges, as seen from a particular direction, is most effective. However, the moment you move, they become more visible.

The **surface** of an object seen with just one eye, as most animals will see you, is mostly defined by the shadows thrown on it. At the same time protruding parts are usually well lit, and any sweat or oily skin on it will shine very prominently.
When applying face paint for camouflage, protruding parts should be coloured as if they are indentations, and the reverse.
Likewise shadows falling on a round object are usually round, and straight on a flat surface. Therefore to hide your surface features, you should have shadows on it that contradicts the real form.

Another aspect of the pattern that works well is one that has **detail at various sizes**. Typically, for the animal to see you as a threat, he must combine what he sees of you into a single "creature". If you are, as the images of such camouflage suggests, you are "close" and "far", you can't be assimilated into one creature, and therefore cannot be "seen".

In further breaking you apart, some of the camouflage should reflect the **foreground**, and some should reflect the background. This situates you at various distances. A patch of sky seen through the bush creates an empty space...

The big advantage of the newest so called digital patterns is that they can create **diffused borders** between colours, cheaply. These diffuse borders make it more difficult to focus on and therefore to do ranging. The animal picks up depth by means of focus (as it sees you with 1 eye), and if it can't focus on you, you are not something.

The last two things we mention is **sound and smell**. Animals can hear and smell vastly better than humans can. Always move slowly, against the wind. Wash with unscented soap, and use unscented deodorants.

One of the single biggest morphological features of animals is **symmetry**. All vertebrate animals are bilateral symmetric.If you are not symmetric, you can't be an animal. Try to break the symmetry of your apparel's left-right sides. If you took two different shirts, cut them diagonally and make two new shirts, you may just laugh the last.

Never confuse camouflage for combat, with that for hunting. Although they can look similar, never judge them with a human eye. Check the patterns at 100 to 10Y. It should stay blotchy and fragmented, and never become a blob of a single colour.

As a last word on camouflage, the best all purpose everywhere camouflage makes you look like something very well known, totally benign, and that's everywhere - a rock. If you walk through the field, how much attention do you apply to rocks? You are always looking at bushes, what's in them, behind them, and as for rocks, at most what's behind them.

Further Reading: Herman Brand, **AB&A**, Aug 2008, p17, *"Become invisible"*
Harry Marx, **AB&A**, May 2008, p58, *"Fashion and the hunter"*
Harry Marx, **AB&A**, Jul 2008, p58, *"Fashion and the hunter"*
Cleve Cheney, **AB&A**, Oct 2007, p20, *"Fooling Animal eyes - Part 1"*
Cleve Cheney, **AB&A**, Nov 2007, p20, *"Fooling Animal eyes - Part 2"*
Cleve Cheney, **AB&A**, Dec 2007, p20, *"Fooling Animal eyes - Part 3"*
Cleve Cheney, **AB&A**, Jan 2008, p20, *"Fooling Animal eyes - Part 4"*
Herman Brand, **AB&A**, Oct 2007, p49, *"Wat bokke sien"*
Peter Netland, **AB&A**, Jun 2007, p15, *"Human scent and the African bowhunter"*
Engee Potgieter, **AB&A**, May 2007, p57, *"How quiet is your bow?"*
Cleve Cheney, **AB&A**, Sep 2007, p14, *"Bushcraft: Winning the scent war"*

4.7   Waiting Times

The time you wait before you start tracking an animal is based very much on the shot placement. You should wait at least 15 minutes for a well placed heart or double lung shot, however even 30 minutes is not overdoing it. For a liver or gut shot, you should wait at least an hour before tracking starts. However, some hunters wait even 3 hours before starting.

When tracking the shot animal, do it as if you are stalking it - very slowly, and carefully. This is not only for safety for you and your PH or guide, but also should it still be alive, and only resting a bit, a noisy tracking party can scare it into the next farm. The old hunters know it's the dead ones that kill you, or that run the furthest...
The best is to wait longer, and even longer when you are unsure of the shot.

4.8   Following a spoor

There are long and beautiful stories of trackers, and how with the faintest of evidences, they can tell you not only where the animal went, but the particular type, male/female, age, temperament, and of course, where they headed. If only we could write down the skill ...

There are only 2 rules when it comes to tracking. The first rule is never walk on the spoor. Walk to the side of it. And if you have a whole group of spectators, keep them way back of the tracking. The dust for your shoes can disturb and hide evidences.

The second rule is to leave it to the expert tracker, or tracker dog, to do the job. You can follow them at a few paces, and for educational purposes also try to see the track.

Sometimes a track or bloodspoor is lost. Don't panic.Sit down, take a deep drink from the water bottle. The tracker will circle around the last spot in an ever growing spiral, and soon pick it up again.

Blood when dried becomes brown. Small spots of blood dry within a minute of two in the hot sun. So you should be looking for brown and red. The blood normally is more smeared against the grasses and bushes as the animal walks, unless of course the bleeding is profuse. The blood gets caught up in the hair much like paint in a paint brush.

Blood has different colour and consistency. Light red, frothy blood is indicative of a lung shot. Light, bright blood is usually arterial blood - a good sign. Dark blood is deoxygenated blood, either coming from the body or internal organs, and indicative of a liver, or body shot. It can mean you are in for a long trek. Watery blood, with stomach contents is a bad sign - indicative of a gut shot. It IS going to be a long trek. If the whole arrow has blood on, it's usually a sure sign of a pass through, and usually a good blood spoor. Antelope and dog blood clots on the ground generally within minutes, while pig blood clots in 3.5 minutes and equine blood (horses, zebras) in 11.5 minutes.

Always remember, it is not the tracker's responsibility to find your trophy - he is doing you a favour. Respect him and show gratitude... and he may just make it his responsibility.

There is a whole bunch of other rules too, but it's more a case of survival than tracking. Never assume a dead animal to be safe - they are the

ones that kill. Never think they are too small to hurt you, or too large to move fast enough. Always keep your eyes open for any other game in your surroundings. With bowhunting, most of the animals will not even know your there - keep it that way. Never assume the animal is dead - the dead ones run the furthest. Do tracking like you would do a walk-and-stalk: slow, looking around, and silent.

Further Reading: Cleve Cheney, **AB**, Nov/Dec 2000, p23, *"Principles of Tracking – Part 2"*
Cleve Cheney, **AB**, Jan/Feb 2001, p17, *"Principles of Tracking: Interpreting Sing – blood trailing – Part 3"*
Cleve Cheney, **AB**, Mar/Apr 2001, p18, *"Principles of Tracking: Interpreting Sing – identification of tracks (mammals) – Part 4"*
Cleve Cheney, **AB&A**, Mar 2008, p74, *"A Tracking Notebook"*
Cleve Cheney, **AB&A**, Feb 2008, p66, *"Tracking by sound"*
Cleve Cheney, **AB&A**, Jan 2008, p74, *"Mud Tracking"*
Cleve Cheney, **AB&A**, Nov 2007, p74, *"Following a blood trail (Part1)"*
Cleve Cheney, **AB&A**, Dec 2007, p74, *"Following a blood trail (Part2)"*
Cleve Cheney, **AB&A**, Oct 2007, p74, *"Tracking: ageing sign – scats"*

4.9   Caping

Further Reading: Kobus Potgieter, **AB&A**, Jun 2007, p30, *"Slag jou trofee reg af"*
Cleve Cheney, **AB&A**, Feb 2008, p20, *"Field dressing a carcass"*
Cleve Cheney, **AB&A**, Mar 2008, p20, *"Skinning your trophy for a shoulder mount"*

4.10   Ethics

There are much written about ethics, and SABA will not say the last word on it. But we (SABA) want to start a process wherewith the bowhunting community can develop a mature and complete education on all aspects of bowhunting, ethics included.
Sometimes ethics is very simple, and most of the times very complicated. Definitely, ethics is subjective, and each hunter has a different view on the specifics.
For example to define one of the most central and common dilemma, a "fair chase", is greatly dependent on the hunter's tools and skills. A seasoned walk-and-stalking bowhunter may see the hunter using a rifle with a scope, who can shoot a head shot at 200m, as unethical - as there is absolutely no chase involved. Likewise someone sitting in a hide can be seen as hunting "unethical" if we require "a fair chase". Likewise, what about from a tree stand, or from behind a bush? Or should we actually be allowed to use camouflage? All these and many other issues are woven around a central concept - they are about practices that make it easier for the hunter to kill. Perhaps a bushman of long ago who have seen today's bows, would shudder in his grave - where's the hunt?
Rifle hunters also just shake their heads in disbelieve. Why would anybody want to shoot with something that needs to be pulled with 70 pounds that you can only shoot at over short distances, etc? To them this bowhunting thing seems like we are trying to make life difficult for ourselves. It is purely a matter of perspective. Many years ago we hunted with rifles from horseback. Today it is illegal to hunt from a vehicle.

Therefore neither SABA nor probably anybody else can define "a fair chase". A really fair chase is probably only when you have to run down your quarry, and bite it to death.

But this discussion hints to an underlying principle. Perhaps the reason for the dilemma in these examples is because the fair chase has nothing to do with ethics?

Hunting ethics should be concerned with the following principals:
1) The targeted animal should experience the least amount of pain, and die as quickly as possible with the least stress.
2) It should be hunted without being a danger to any other animals or people (including you)
3) It should be by legal means.

If we all can accept these points, we need not have any argument on ethics. Anything that is not solved by referring back to these principles, becomes opinions, and is subjective, and most probably will change in time and among cultures as well. Then a "fair chase" lies outside the scope of ethics, and becomes one of opinion.

Rean Steenkamp, editor of the African Bowhunter and Archer, has the following to say:
"Hier is daar twee goed wat teenmekaar opgeweeg word, naamlik etiese jag en "fair chase". Om met 'n boog 'n dier te bekruip is meer "fair chase" as met 'n geweer, maar minder eties. Jy kan tog meer sekuur skiet met 'n geweer en 'n teleskoop. En die geweer bied meer skote op die bok. Kanse om droog te maak met 'n loop-en-bekruip jag is ook meer as vanuit 'n skuiling skiet. Skuilingskiet is dus meer eties, maar minder "fair chase"."
This illustrates the difference between ethics, opinion and a fair chase. The most important implication of these principles is that you have to shoot accurately, not with marginal or inferior equipment, and only if a safe and sure shot is available. This applies to ALL types of hunting.
Just one small definition before we continue, when is an arrow shot a wound, and when not? Wounding is when the animal does not die due to **loss of blood pressure** (blood loss due to internal or external bleeding, or heart failure), **asphyxiation** (internal bleeding into the lungs), **direct neural damage** (spinal or brain shot), or **cutting off the blood supply to the brain** (severing for example carotid arteries).

Before even ethics come the rules of bowhunting. These are simple and leave very little to interpretation.
1) The hunter must know what he/she wants to hunt, and make sure their equipment is adequate.
2) The hunter must be able to demonstrate groupings that support the distance he/she holds forward to hunt a particular species.
3) The hunter must know what species and gender are available, and which are not.
4) The hunter must know and follow the farm rules.
5) No head shots and no shots from directly behind an animal.
6) No alcohol before or during the hunt.
7) If your arrow drew blood, you pay for the hunt.
8) You pay for what you shot, not what you thought you shot.

On these last rules: SABA supports the very old and universal rule, if you draw blood, you pay. There is no responsibility on the farmer's side, or the PH, or the manager, to find the animal you shot. It was your decision to hunt there, and you must have inquired on the policy of the farmer, if they have good trackers, perhaps trained dogs, etc. If you shoot and there is blood on the

scene, you must pay. Likewise if the carcass is only found the next day and there is not much left. It is the right of the farmer to refuse you any further hunting or even access to his land, if you do not follow this rule. Likewise, if you feel you were not treated well, it is your right to hunt elsewhere. And if you want to shoot an Oryx and the guide/PH or whoever is with you, say go, and it's a sable antelope, you pay. If you respect these people, their animals and their rules, they will make it their responsibility to find your trophy.

SABA also supports what can be called good hunting manners:

1) Inform the farmer on the equipment you use. Even the colours of your fletching come to mind.

2) Declare the arrows you take to the hunt, and those you return with.

3) Demonstrate accuracy, and do a few practice shots each day.

4) Discuss shot placement with the farmer or PH, they may have very valuable experience in this regard - never think you know more than they do.

5) When taking photos try to limit the amount of blood. It just creates a nicer picture that way.

6) When you write an article on a hunt, don't praise yourself. Praise the animal. It died for you.

7) Realize the privilege, and not the right to hunt.

8) Be prepared - you are there to hunt - your set-up should have been done long ago.

SABA requires as part of their proficiency program, for hunters to actively practice and partake in competitions.

And lastly SABA wants all hunters to have done a proficiency certification, preferably of course SABA's, but definitely at least any.

Here are a few easy and not so simple situation and opinions regarding hunting practices:

    a) There is another animal standing behind the one you want to shoot.
        This clearly violates the safety principal. If you have adequate equipment and places a good shot, there is a huge probability that the arrow or bullet will pass right through the targeted animal, and wound the one behind it. If there is no chance of a pass through, you are maybe using a marginal set-up, which violates the death principal.

    b) There are grasses or twigs in front of the animal you want to shoot.
        This would clearly violate your chances of a sure shot, would it not? Especially if you are using mechanical hunting points, as the grasses can cause the blades to open prematurely, and unbalance the broadhead, leading to wounding the animal. Using a heavy hunting point with very heavy arrow, say 800gr, and a target at 10Y, the effect of a small blade of grass can be questioned. In this case we are clear that the death principle is involved, but the degree of violation is in question.

    c) The animal is moving.
        The arrow is going to take roughly between 0.2 and 0.4 seconds to get to the animal. If the animal decides to stop when you release the arrow, you could miss or wound it. Worse, the arrow will be travelling at an angle towards the animal, which may impede penetration. Remember when it walks it also moves up and down, and its leg bones changes position. Most bowhunters consider shooting at a walking animal as unethical as there is a chance of violating the death principle.

    d) Shooting across the wind.
        Even if you practiced shooting across a strong wind, and can adjust the sight precisely to compensate, the arrow will hit the animal at an angle. This

angle SEVERELY impedes penetration. You can test this easily on a butt. It's the same effect you get when you hit a nail with a hammer, and the nail is not perpendicular to the hammer's stroke - you end up with a blue thumb and zero penetration. This issue is to what degree is the death principle being violated.

e) Very alert animals, or animals looking at you.
    This increases the animal's readiness to jump. It means that the reaction time we thought to be safe is now totally inadequate. A sure shot is highly unlikely. There is therefore a chance of violating the death principle.

f) The animal is standing towards you, or away from you.
    Texas heart shots do not work for bow hunting. No further discussion.
    Frontal shots require extreme accuracy. And even if you shoot a perfect shot, and the animal moves 1", you could end wounding it. The average bowhunter should not consider this shot. Here is a high probability of violating the death principle.

g) A female animal (cow, ewe or sow) is with dependent young.
    Killing it will cause suffering and death to dependent young. This will be a direct violation of the safety violation - safety to other animals.

h) The animal is on top of a hill.
    Even with, and especially with a perfect hit, a possible pass through can wound or injure anything behind the hill. Even if you know there isn't a little village within 1000Y behind the hill, there may be a whole gathering today. Remember that arrows have been shot in access of 1000Y! Therefore a possibility exists of violating the safety principle.

i) From a vehicle, from a tree stand, from a hide?
    None of the listed ethical principles are broken by doing this. The basis on which people decide the acceptability of these practices is again the "fair chase" issue. Many years ago we hunted from horseback. Likewise what about distance, would it be fair to shoot an animal with a sniper's rifle at 500m? Perhaps you say the hunting technique is not the factor defining a "fair chase", but the skill of the hunter needed to do the hunt. But what happens if you could shoot a 4" grouping with a bow at 100Y? Would it not be for you "unfair" to hunt at a mere 20Y? The same amount of shooting skill is needed whether you shoot from a hide or a when stalking. When stalking, additional skills are needed.
    This is therefore seen as a matter of opinion, and not of ethics. The more ethical (safe and sure) the shot becomes, the less of chase it was.

j) Hunting at a waterhole / feeding point / with bait
    This is again the "fair chase" issue. See item (i) on this. Using bait for hunting cats is currently illegal. Hunting cats is currently illegal, without special permits. We can probably all agree that "canned" hunting involves no chase, but is it unethical? It is also very difficult to draw a line where the "can" ends and "fair" begins. Is it acceptable to throw veggies for bush pigs, but not a leg of lamb for a lion?
    Therefore it becomes an opinion, and not an issue of ethics.

k) Using a rangefinder:
    You can argue that using a rangefinder degreases the "fairness" of the chase, or that it decreases chances of wounding the animal. Almost all bowhunters are not able to judge distance within the limits needed by bowhunting. Therefore it is recommended that you always use a rangefinder or another method to determine ranges to within required limits.
    A typical hunting arrow has a speed of 250 fps. For an Impala, with a vital area diameter of about 4", and using 1" as a safety factor, you are allowing only 1" above and below your grouping size. For your grouping to use up the whole safety margin your estimation only have to be out by 32" at 20Y, 21" at 30Y and 18" at 40Y. This implies that if you want to hunt safely and surely an Impala at 40Y, you need a rangefinder that can measure distance to at least 0.5Y accurately.
    It is therefore proposed to be unethical to hunt without it - there is a chance of violating the death principle.

l) To hunt with a very low poundage bow.
    Every now and then we hear how an animal was shot with a 24lbs or so bow. This can be done. A knife can kill a buck. But the chance of this not succeeding is great. If the hunting point is not extremely sharp, and selected with maximum penetration in mind, and it glances of even a smallish bone, it can

mean a horrible experience for the hunter and the hunted. SABA and the rest of the bowhunting community would not want to exclude children, women, traditional hunters and people with disabilities, from hunting if they are so inclined. However, the reality is the bigger the chance you take, the bigger the probability to fail, and the stronger opposition there will be against the whole of hunting when you do. Minimum requirements are a necessity for bowhunting if it should continue to exist as a lawful way to hunt.

It creates a degree of violation of the death principal when not adhering to recommendations based on sound hunting practice.

m) Low light conditions

At first glance this does not break any of the principles. However, if you wanted to hunt a male steenbok, and ends up shooting a male duiker, you could be in serious problems. Mistakes on gender are extremely easy where both sexes have horns, for ex. Oryx (Gemsbok), Blue-wildebeest. And sometimes a farm rule can be in effect: don't shoot the females, you pay double for them, or something to that extend. Where the targeted species may be available for hunting, the shot species may be highly endangered, and it is most probably illegal to hunt. On second thought, when shooting at an unidentified animal, a big chance exists for breaking the safety principle. Chances are that if you could not identify it, you could not see the vital area, and then you violate the death principle as well.

n) Head, neck and spinal shots

It is quite clear that some none-wounding shots are not considered "ethical", for example executing spinal shots on purpose. However, such a shot would in fact lead to a much quicker death, and sometimes a totally painless one as well. How can such shots be seen as unethical? Very simply, there is a great probability to miss with such a shot, as the target is very small. The target in the case of the spinal cord and brain is also protected by strong bones, creating a probability of not penetrating deep enough. In these cases where the animal was not killed it would lead to a wound. Therefore even though the shots would be perfectly effective, they are unethical as the chance of violating the death principle is too big.

o) Exploding or poisoned points

These practices are illegal. But for argument's sake, we will ignore this. It is very much possible to set up an exploding charge in the arrow's tip. We also ignore the safety principle for now. It could be set up to be only strong enough as to impart a systemic shock equal to that of a penetrating bullet. Would it not then be as ethical as hunting with a rifle? It then becomes a matter of opinion.

There are various types of "poisons". Some will kill the animal with pain, some without pain. Some works quickly, some don't. Some if administered in a too low dosage will have no side effects, and some will. So clearly, if again we ignore the legality and safety principles, then we can end up with a chemical that kills painlessly and quickly, without any after effects if a sub-dosage occurs. Definitely it becomes a matter of opinion then.

In both these cases however, usage of these methods may lead to the hunter relying on the chemicals, and not accuracy, to kill. Now it can be a violation of the death principle for the exploding points, but an opinion for poisons (they work from anywhere).

Of course both these methods are illegal, due to licensing issues and public opinion, so they are not ethical.

So in summary, if an act violates any of the ethical principles, it is unethical. Some acts violate it to a degree, and some acts contain a probability of violation. In all these cases, the hunter takes the responsibility of his actions, which can lead from being barred from hunting to legal action.

🪶If there is any reason to query the ethics of a shot, query it, for it is probably on the verge of being unethical, and therefore, already so.

One of the biggest issues we just touched is marginal equipment. This subject is however so large, that it fills almost a whole proficiency program.

Further Reading: Sampie Stoffberg, **AB&A**, Sep 2008, p60, *"Etiese Jag en boog pioniers"*
Dieter Noli, **AB&A**, Apr 2008, p71, *"Canned Hunting"*
Dieter Noli, **AB&A**, Feb 2008, p71, *"Should we poison our arrows?"*
Cleve Cheney, **AB&A**, Jul 2006, p37, *"The Ethics and morality of bowhunting (Part 1)"*
Cleve Cheney, **AB&A**, Aug 2006, p37, *"The Ethics and morality of bowhunting (Part 2)"*
Cleve Cheney, **AB&A**, Sep 2006, p44, *"The Ethics and morality of bowhunting (Part 3)"*
Cleve Cheney, **AB&A**, Oct 2006, p45, *"The Ethics and morality of bowhunting"*
Cleve Cheney, **AB&A**, Nov 2006, p20, *"The Ethics and morality of bowhunting"*
Cleve Cheney, **AB&A**, Dec 2006, p22, *"The Ethics and morality of bowhunting"*
Cleve Cheney, **AB&A**, Jan 2007, p34, *"The Ethics and morality of bowhunting"*
Herman Brand, **AB&A**, Jun 2007, p29, *"Respek"*
Anthony C. Ruggeri, **AB&A**, Dec 2007, p36, *"Blinds versus Walk and Stalk"*

4.11   Conclusion

Please take note that although these recommendations are based on hunting experiences, it does not guarantee a successful hunt. It also follows that it is possible to hunt successful, although usually not lawful/ethical, by not adhering to them. Currently the law prescribes some equipment requirements, but makes no mention of the archer's abilities. The equipment provides penetration, while the archer provides accuracy, and it is on this point that we base our recommendations.

As best situation, we recommend that the optimum arrow mass always be met. The optimum velocity or momentum as suggested is subject to the hunting point's ability to cut flesh (Ro value). An arrow should ideally exceed the suggested velocity.

4.12   Some miscellaneous reading

Further Reading: Engee Potgieter, **AB&A**, Aug 2007, p39, *"Take better trophy photos"*
Cleve Cheney, **AB&A**, Oct 2007, p15, *"Building blinds for bowhunting"*
Louis Stoffberg, **AB&A**, Jun 2008, p55, *"Bou 'n Gawe Skuiling"*
Harry Marx, **AB&A**, Jan 2009, p11, *"The cheapest chronograph yet"*
Harry Marx, **AB&A**, Dec 2007, p19, *"A 'cheap' Chronograph"*
Cleve Cheney, **AB&A**, Jun 2008, p20, *"Bushcraft: Fire"*

5 Species

5.1 Species Categories

The use of any two of KE, mass, momentum and speed, implies the other two as well. KE and momentum is derived from both <u>and only</u> velocity and mass. Two different arrows may have similar KE, but one may be unsuitable for hunting due to low mass and very high velocity. It is therefore mathematical tautology to use KE and momentum, as it mathematically, and exactly, fixes the mass and velocity, and therefore a simpler formulation would only have included a minimum mass and a minimum velocity. Both can be measured, and no mathematical formula are needed.

The tables are based on momentum correlating penetration. E_k values of more than 120 are assumed not achievable ("n.a."). .

5.1.1 Categories

5.1.1.1 Category 0

Small mammals and game Birds, except Ostrich

```
Animal mass             less than 5kg
Recommended Arrow mass  300+ gr
Max hunt distance***    20Y
Vitals' diameter****    2"
Required speed          200 fps
Hunting point           Blunts, Judo, broadheads.
```

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5.1.1.2 Category 1

Animals up to size of the Blesbuck, excluding Warthog and Bush pig, including Nyala female but not the male, exclude predators larger than black backed jackal. All game birds except Ostrich. Primates up to baboon.

```
Animal mass              less than 60kg
Recommended Arrow mass   300+ gr
Max hunt distance***     20Y
Vitals' diameter****     4"
Required penetration⁺     7.75"
Rib strength             12.5 vt.lbs
```

For various arrow weights (columns) and broadheads (rows), you need the following speeds to achieve the required penetration:

(sq.inch) A	(lbs) Ro	Arrow Weight 350	350	350	350	
1.0	3	161	184	189	214	
1.1	4.5	163	187	194	220	sleek 2 bladers
1.1	6	166	189	200	227	medium 2 bladers
1.2	8	170	193	210	237	large 2 bladers
1.3	9.5	173	197	219	247	small 3 bladers
1.3	11	177	201	231	259	
1.4	12.5	181	206	245	273	medium 3 bladers
1.4	14	187	212	263	290	small 4 bladers
1.5	15	191	217	278	304	3 blade mechanicals/ large 4 bladers

(sq.inch) A	(lbs) Ro	Arrow Weight +100 450	450	450	450	
1.0	3	159	178	181	200	
1.1	4.5	162	180	184	203	sleek 2 bladers
1.1	6	164	182	188	207	medium 2 bladers
1.2	8	167	184	193	213	large 2 bladers
1.3	9.5	169	187	199	219	small 3 bladers
1.3	11	171	189	205	225	
1.4	12.5	174	192	212	233	medium 3 bladers
1.4	14	177	196	221	243	small 4 bladers
1.5	15	180	198	229	250	3 blade mechanicals/ large 4 bladers

(Broadhead cutting resistance Ro)

Please note the first column indicate speed needed if no bone is touched, the 2nd column adds energy for 1 rib on entry, the 3 column for 1 rib on exit, and the 4th for 2 ribs. Coulored cells are below, and grey cells above as prescribed by SA-Norms and Standards

5.1.1.3   Category 2

Up to the size of the female Kudu, including the Black Wildebeest, Bush pig, Warthog, all predators except Lion, Leopard, as well as Ostrich, excluding the Gemsbok, and Sable.

```
Animal mass              less than 200kg
Recommended Arrow mass   400 gr
Max hunt distance        25Y
Vitals' diameter         5"
Required penetration+     14"
Rib strength             17 vt.lbs
```

For various arrow weights (columns) and broadheads (rows), you need the following speeds to achieve the required penetration:

A (sq.inch)	Ro (lbs)	Arrow Weight 400	400	400	400	
1.0	3	164	192	204	236	
1.1	4.5	169	196	216	248	sleek 2 bladers
1.1	6	173	201	231	264	medium 2 bladers
1.2	8	181	210	256	288	large 2 bladers
1.3	9.5	189	219	282	312	small 3 bladers
1.3	11	199	231	313	341	
1.4	12.5	213	246	n.a.	n.a.	medium 3 bladers
1.4	14	233	266	n.a.	n.a.	small 4 bladers
1.5	15	251	283	n.a.	n.a.	3 blade mechanicals/ large 4 bladers

A	Ro	Arrow Weight + 100 500	500	500	500	
1.0	3	162	184	192	216	
1.1	4.5	166	188	199	224	sleek 2 bladers
1.1	6	169	191	207	233	medium 2 bladers
1.2	8	175	197	222	248	large 2 bladers
1.3	9.5	180	203	237	263	small 3 bladers
1.3	11	186	209	255	281	
1.4	12.5	194	218	278	303	medium 3 bladers
1.4	14	204	229	305	329	small 4 bladers
1.5	15	213	239	329	n.a.	3 blade mechanicals/ large 4 bladers

(Broadhead cutting resistance Ro)

Please note the first column indicate speed needed if no bone is touched, the 2nd column adds energy for 1 rib on entry, the 3 column for 1 rib on exit, and the 4th for 2 ribs. Coulored cells are below, and grey cells above as prescribed by SA-Norms and Standards

5.1.1.4 Category 3

Bigger species up to the Eland, inclusive of the Lion* and Leopard* (where allowed), Blue wildebeest, Kudu bull, Sable and Gemsbok. Excluding Buffalo

```
Animal mass              less than 800kg
Recommended Arrow mass   500 gr
Max hunt distance        30Y
Vitals' diameter         6"
Required penetration⁺    28"
Rib strength             24 vt.lbs
```

Required penetration[+]

For various arrow weights (columns) and broadheads (rows), you need the following speeds to achieve the required penetration:

(sq.inch) A	(lbs) Ro	Arrow Weight 500	500	500	500	
1.0	3	171	202	243	280	
1.1	4.5	179	212	275	310	sleek 2 bladers
1.1	6	192	226	315	347	medium 2 bladers
1.2	8	216	253	n.a.	n.a.	large 2 bladers
1.3	9.5	246	283	n.a.	n.a.	small 3 bladers
1.3	11	288	322	n.a.	n.a.	
1.4	12.5	344	n.a.	n.a.	n.a.	medium 3 bladers
1.4	14	n.a.	n.a.	n.a.	n.a.	small 4 bladers
1.5	15	n.a.	n.a.	n.a.	n.a.	3 blade mechanicals/ large 4 bladers

		Arrow Weight 600	+ 100 600	600	600	
1.0	3	168	193	219	250	
1.1	4.5	174	201	239	270	sleek 2 bladers
1.1	6	183	210	266	296	medium 2 bladers
1.2	8	198	228	311	338	large 2 bladers
1.3	9.5	216	246	n.a.	n.a.	small 3 bladers
1.3	11	241	272	n.a.	n.a.	
1.4	12.5	276	305	n.a.	n.a.	medium 3 bladers
1.4	14	321	348	n.a.	n.a.	small 4 bladers
1.5	15	n.a.	n.a.	n.a.	n.a.	3 blade mechanicals/ large 4 bladers

(Broadhead cutting resistance Ro)

Please note the first column indicate speed needed if no bone is touched, the 2nd column adds energy for 1 rib on entry, the 3 column for 1 rib on exit, and the 4th for 2 ribs. Coulored cells are below, and grey cells above as prescribed by SA-Norms and Standards

5.1.1.5 Category 4

Buffalo female, Giraffe female
```
     Animal mass              800-2000kg
     Recommended Arrow mass   800 gr
     Max hunt distance        40Y
     Vitals' diameter         6"
     Required penetration+    30"
     Rib strength             30 vt.lbs
```
For various arrow weights (columns) and broadheads (rows), you need the following speeds to achieve the required penetration:

(sq.inch) A	(lbs) Ro	Arrow Weight 800	800	800	800	
1.0	3	171	196	171	196	
1.1	4.5	181	206	181	206	sleek 2 bladers
1.1	6	194	221	194	221	medium 2 bladers
1.2	8	221	250	221	250	large 2 bladers
1.3	9.5	253	282	253	282	small 3 bladers
1.3	11	298	324	298	324	
1.4	12.5	n.a.	n.a.	n.a.	n.a.	medium 3 bladers
1.4	14	n.a.	n.a.	n.a.	n.a.	small 4 bladers
1.5	15	n.a.	n.a.	n.a.	n.a.	3 blade mechanicals/ large 4 bladers

(sq.inch) A	(lbs) Ro	Arrow Weight + 200 1000	1000	1000	1000	
1.0	3	168	187	168	187	
1.1	4.5	174	194	174	194	sleek 2 bladers
1.1	6	182	202	182	202	medium 2 bladers
1.2	8	197	219	197	219	large 2 bladers
1.3	9.5	214	237	214	237	small 3 bladers
1.3	11	237	261	237	261	
1.4	12.5	270	292	270	292	medium 3 bladers
1.4	14	312	333	312	333	small 4 bladers
1.5	15	n.a.	n.a.	n.a.	n.a.	3 blade mechanicals/ large 4 bladers

Broadhead cutting resistance Ro

Please note the first column indicate speed needed if no bone is touched, the 2nd column adds energy for 1 rib on entry, the 3 column for 1 rib on exit, and the 4th for 2 ribs. Coloured cells are below, and grey cells above as prescribed by SA-Norms and Standards

5.1.1.6   Category 5

Giraffe male, buffalo male, crocodile

Animal mass	+1200kg
Recommended Arrow mass	900 gr
Max hunt distance	40Y
Vitals' diameter	7"
Required penetration[+]	40"
Rib strength	40 vt.lbs

For various arrow weights (columns) and broadheads (rows), you need the following speeds to achieve the required penetration:

Broadhead cutting resistance Ro

(sq.inch) A	(lbs) Ro	Arrow Weight 900	900	900	900	
1.0	3	169	198	169	198	
1.1	4.5	177	207	177	207	sleek 2 bladers
1.1	6	187	218	187	218	medium 2 bladers
1.2	8	206	240	206	240	large 2 bladers
1.3	9.5	229	264	229	264	small 3 bladers
1.3	11	261	295	261	295	
1.4	12.5	305	335	305	335	medium 3 bladers
1.4	14	n.a.	n.a.	n.a.	n.a.	small 4 bladers
1.5	15	n.a.	n.a.	n.a.	n.a.	3 blade mechanicals/ large 4 bladers

Arrow Weight + 200

(sq.inch) A	(lbs) Ro	1100	1100	1100	1100	
1.0	3	166	190	166	190	
1.1	4.5	172	196	172	196	sleek 2 bladers
1.1	6	179	203	179	203	medium 2 bladers
1.2	8	191	216	191	216	large 2 bladers
1.3	9.5	203	231	203	231	small 3 bladers
1.3	11	221	249	221	249	
1.4	12.5	246	274	246	274	medium 3 bladers
1.4	14	279	305	279	305	small 4 bladers
1.5	15	308	333	308	333	3 blade mechanicals/ large 4 bladers

Please note the first column indicate speed needed if no bone is touched, the 2nd column adds energy for 1 rib on entry, the 3 column for 1 rib on exit, and the 4th for 2 ribs. Coulored cells are below, and grey cells above as prescribed by SA-Norms and Standards

5.1.1.7 Category 6

Elephant* (where allowed). Black and white rhinoceros* and hippopotamus*.

        Animal mass   +5000kg
        Recommended Arrow mass   1000 gr
        Max hunt distance   40Y
        Vitals' diameter   8"
        Required penetration[+]   50"
        Rib strength   40 vt.lbs

For various arrow weights (columns) and broadheads (rows), you need the following speeds to achieve the required penetration:

Broadhead cutting resistance Ro

(sq.inch) A	(lbs) Ro	Arrow Weight 1000	1000	1000	1000	
1.0	3	170	195	170	195	
1.1	4.5	178	204	178	204	sleek 2 bladers
1.1	6	188	216	188	216	medium 2 bladers
1.2	8	208	238	208	238	large 2 bladers
1.3	9.5	232	263	232	263	small 3 bladers
1.3	11	265	295	265	295	
1.4	12.5	310	337	310	337	medium 3 bladers
1.4	14	n.a.	n.a.	n.a.	n.a.	small 4 bladers
1.5	15	n.a.	n.a.	n.a.	n.a.	3 blade mechanicals/ large 4 bladers
		Arrow Weight 1200	+ 200 1200	1200	1200	
1.0	3	167	188	167	188	
1.1	4.5	173	194	173	194	sleek 2 bladers
1.1	6	180	202	180	202	medium 2 bladers
1.2	8	193	217	193	217	large 2 bladers
1.3	9.5	207	232	207	232	small 3 bladers
1.3	11	226	252	226	252	
1.4	12.5	253	279	253	279	medium 3 bladers
1.4	14	289	313	289	313	small 4 bladers
1.5	15	321	343	321	343	3 blade mechanicals/ large 4 bladers

Please note the first column indicate speed needed if no bone is touched, the 2nd column adds energy for 1 rib on entry, the 3 column for 1 rib on exit, and the 4th for 2 ribs. Coulored cells are below, and grey cells above as prescribed by SA-Norms and Standards

```
Category 1-3 should have a point with blade heights of at least Ø 0.35" (9mm)
    (cutting diameter 1")
Category 4 and above should have two blades with blade heights of at least Ø
0.4" (10mm),
    with a cut-on-contact tip (cutting diameter 1.1").
Category 6 no bleeder blades.
```


*According to South African legislation, at the date of this writing, no bowhunting of the listed, threatened or protected species, and pachyderms or chick-skinned animals is allowed in South Africa, except in the case of controlling damage causing animals. These species include:

- elephant
- hippopotamus
- rhinoceros
- cape mountain zebra
- cheetah
- crocodile
- lion
- leopard
- caracal
- porcupine
- common duiker
- Cape fox
- swart poot kat
- small spotted cat
- hartman's zebra
- all primates
- otter
- aardvark
- ietermago/pangolin

```
It is important to note that bowhunters must adhere to the various provincial
rules and regulations, as well as national rules and regulations.

As said, these animals are protected in South Africa, but maybe not in the rest
of Africa, where other species may be under protection there. Therefore we
include them here for reference, should they be available were hunted, but you
will have to as ethical hunter, make sure you have local and up to date
information.

**Velocity is subject to a PI of 1 for the hunting point, a shaft factor of 1,
and a mass factor of 1.

***Maximum yardage is based on a reaction time from animals and an arrow
velocity of 250fps.

****The Vitals' Area Diameter (VAD) is defined as the diameter of the largest
circle that fits inside the shot window to the vital organs (heart and lungs)
that miss all the major bones.

+ Required Penetration Depth (RPD) is the depth to which a fieldpoint on an
```

arrow with this speed and weight, according to Poncelet, would have penetrated in flesh.

5.2 Common species names and proposed category

Categories are based on the animal's weight, and to a degree on what could be considered its "toughness" and the "danger" of hunting it, and as such is fairly arbitrary. It stands to reason therefore that for young animals of a species a lower category would be more applicable, and for some exceptional large individuals, a higher general category may be more appropriate.

Temperament is if course a highly subjective issue, for the hunter and the hunted. There are some species differences, but a bigger difference is due to circumstances. It is suggested you take cognizance of the animal's behavior to determine temperament, and to adjust maximum yardages accordingly.

In general the temperament can be compared to reaction times, and the following is suggested:

- reasonably calm   use table as is

- cautious   about halfway between animal's category and one smaller

- nervous   use one categories smaller – about a 20% reduction

See the table on maximum distances based on reaction times for the effect this should have on your shooting. Temperament should override any other species or accuracy concerns.

Average mass is provided as a range, a carcass %, and carcass weight, in kg.

5.2.1 Black Wildebeest (*Connochaetes gnou*)
category #2

 Average Mass: 90-160, 55%, 50-80
Temperament: Cautious
Average Shoulder Height: F:110cm
  M:120cm (47")
Rowland Ward: 58.11cm (22 7/8")
  max 29 3/8"
SCI: 72 Points max 29 1/2
Track: 89mm (3 1/2") x 61mm (2 3/8")
Equipment: 400gr @ 250fps, Ro<12

Further Reading: Engee Potgieter, **AB&A**, Jan 2008, p27, *"Black Wildebeest:Icon of the open plains"*

5.2.2 Blesbuck (*Damaliscus dorcas phillipsi*)
category #1


```
   Average Mass:   60-80, 53, 32-44
Temperament: Cautious
Average Shoulder Height: 95cm (37")
Rowland Ward:  41.91cm (16 1/2")
  max 20 5/8"
SCI:    39 Points max 54 7/8
Track: 64mm (2 1/2") x 45mm (1 3/4")
Equipment: 350gr @ 250fps, Ro<16
```

Further Reading: Cleve Cheney, **AB&A**, Sep 2007, p8, *"Hunting Blesbok"*
Engee Potgieter, **AB&A**, Sep 2007, p10, *"Bowhunting the boring blesbok"*
Anthony C. Ruggeri, **AB&A**, Sep 2007, p20, *"Blesbok: The Plain's game little big man"*

5.2.3 Blue Wildebeest (*Connochaetes taurinus taurinus*)
category #3


```
Average Mass:   215-250, 58, 125-145
Temperament: Reasonably calm
Average Shoulder Height:   F:135cm
    M:150cm
Rowland Ward:   72.39 cm (28 1/2")
    max 33 7/8
SCI:    70 Points  max 94 3/4
Track: 86mm (3 3/8") x 61mm (2 3/8")
      Equipment: 600gr @ 250fps, Ro<12
```
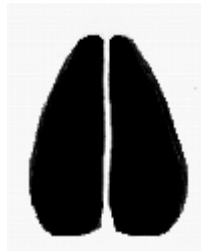

Further Reading: Cleve Cheney, **AB**, Jan/Feb 2001, p8, *"Bowhunting Blue Wildebeest"*
Cleve Cheney, **AB&A**, Jun 2008, p8, *"Hunting Blue Wildebeest"*
Jerry Pilling, **AB&A**, Jun 2008, p12, *"Waiting for a wildebeest"*

5.2.4   Buffalo (*Syncerus caffer caffer*)
female:category #4, male:/>category #5
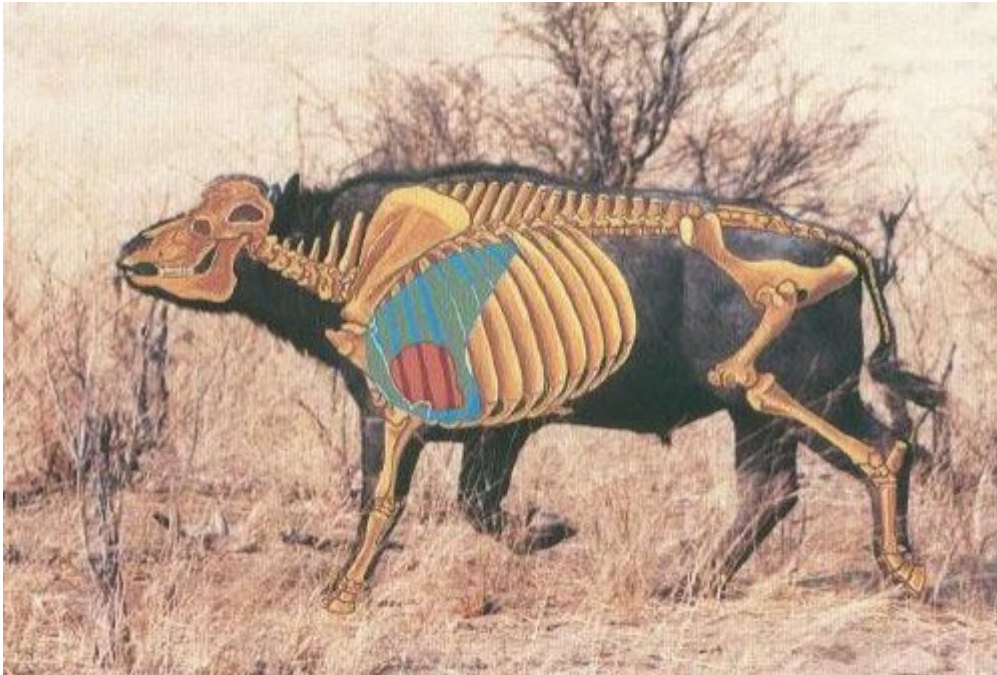

```
Average Mass:   680-820, 50, 340-410
Temperament: Reasonably calm
Average Shoulder Height: 170 cm (67")
Rowland Ward:   114.30 cm (45")
SCI:    100 Points
Track: 152mm (6") x 152mm (6")
     Equipment: 800 gr @ 220, 900gr @ 215fps, Ro<8
```


Further Reading: Piet Lombard, **AB&A**, Apr 2007, p9, *"Buffalo hunt on the run"*

5.2.5   Bush Buck (*Tragelaphus scriptus sylvaticus*)
category #1


```
Average Mass:   63-73, 55, 35-40
Temperament: nervous
Average Shoulder Height: 80 cm (31")
Rowland Ward:   38.10 cm (15")
SCI:    31 Points
Track: 41mm (1 5/8") x 25mm (1")
     Equipment: 350gr @ 250fps, Ro<12
```


Further Reading: Cleve Cheney, **AB&A**, Jul 2008, p8

5.2.6 Bushpig (*Potamochoerus porcus*)
category #2


```
Average Mass:    65
Temperament: nervous
Average Shoulder Height:  75 cm (30")
Rowland Ward:   13.97 cm (5 1/2")
SCI:    11 Points
Track: 41mm (1 5/8") x 38mm (1 1/2")
     Equipment: 400gr @ 250fps, Ro<10
```

Further Reading: Engee Potgieter, **AB&A**, Oct 2008, p28
Cleve Cheney, **AB&A**, Dec 2007, p8, *"Hunting the Feral Pig"*
Adrian de Villiers, **AB&A**, Dec 2007, p27, *"Bowhunting Feral Pigs"*

5.2.7   Caracal(rooikat) (*Caracal caracal*)
category #2


```
Average Mass:   7 - 19 kg
Temperament: nervous
Average Shoulder Height: 40 - 45 cm (17")
Rowland Ward:  19.05 cm (7 1/2")
SCI:  6 Points
Track:  51 x 51 mm(2")
     Equipment: 350gr @ 250fps, Ro<12
```

5.2.8   Cheetah (*Acinonyx jubatus*)
category #2


```
Average Mass:   63
Temperament: nervous
Average Shoulder Height: 86 cm (34")
Rowland Ward:   31.44 cm (12 3/8")
SCI:    12 Points
Track: 105mm (4 1/8") x 86mm (3 3/8")
     Equipment: 400gr @ 250fps, Ro<12
```

5.2.9 Crocodile (*Crocodilus nilotica*)
category #5


```
  Average Mass:   910
 Temperament: Reasonably calm
 Average length: 5.5m + (18 '+)
 Rowland Ward:   4.27m (14') length
 SCI:    2.75 m (9 ')
 Track:
  Front: 180mm (4 1/4") x 150mm (4 1/4")
  Hind: 180mm (4 1/4") x 150mm (4 1/4")
 Equipment: 900gr @ 200fps, Ro<10
```

5.2.10 Duiker (*Cephalophus monticola*)
category #1


```
Average Mass:   10-14, 55, 6-8
Temperament: Cautious
Average Shoulder Height: 30 cm (12")
Rowland Ward:   4.44 cm (1 3/4")
SCI:    4 Points
Track: 41mm (1 5/8") x 25mm (1")
     Equipment: 350gr @ 250fps, Ro<12
```
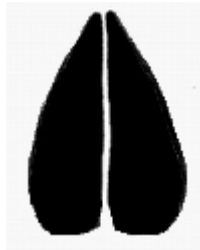

Further Reading: Cleve Cheney, **AB&A**, Jan 2007, p8, *"Hunting the Blue Duiker"*
Cleve Cheney, **AB&A**, Nov 2008, p8

5.2.11   Eland   (*Taurotragus oryx livingstonii*)
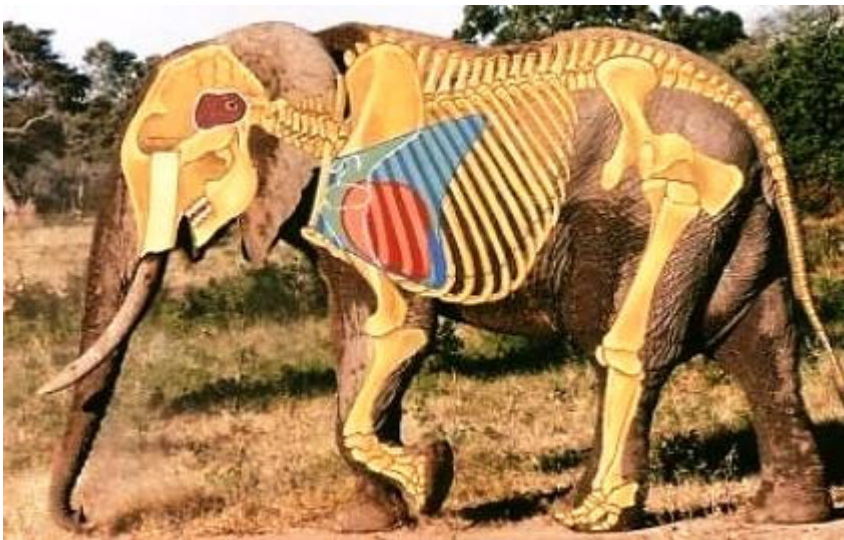
category #3


```
    Average Mass:   460-910, 51, 235-464
    Temperament: Cautious
    Average Shoulder Height: 170 cm (67")
    Rowland Ward:   88.90 cm (35")
    SCI:    77 Points
    Track: 114mm (4 1/2") x 95mm (3 3/4")
        Equipment: 600gr @ 250fps, Ro<10
```


Further Reading: Cleve Cheney, **AB&A**, Oct 2008, p8
Anthony C. Ruggeri, **AB&A**, Jan 2007, p27, *"Eland"*

5.2.12   Elephant (*Loxodonta africana*)

category #6


```
Average Mass:   5700
Temperament: Reasonably calm, but can be
nervous
Average Shoulder Height: 350cm (138")
Rowland Ward:  36.36kg (80lb)
SCI:    100 Points
Track: 533mm (21") x 483mm (19")
     Equipment: 1200gr @ 200fps, Ro<5
```


Further Reading: Fritz Rabe, **AB&A**, Oct 2006, p36, *"Elephant Bowhunt"*
Hendrik Von Wielligh, **AB&A**, Aug 2007, p19, *"Musth in Male African Elephants"*

5.2.13   Fallo Deer   (*Cervus dama dama*)
category #1


```
Average Mass:    68
Temperament:
Average Shoulder Height:    91 cm (36")
Rowland Ward:    64.13 cm (25 1/4")
SCI:    130 Points
Track: 73mm (2 7/8") x 44mm (1 3/4 ")
      Equipment: 350gr @ 250fps, Ro<12
```

5.2.14 fox (*Otocyon megalotis*)
category #1


```
Average Mass:   3 - 4.5kg
Temperament: shy, nervous
Average Shoulder Height:    35-40 cm (16")
Rowland Ward:
SCI:
Track:
     Equipment: 350gr @ 250fps, Ro<12
```

5.2.15   Gemsbok (*Oryx gazella gazella*)

category #3


```
Average Mass:   180-210, 55, 99-118
Temperament: Cautious
Average Shoulder Height:    120 cm (47")
Rowland Ward:   101.60 cm (40")
SCI:    88 Points
Track: 95mm (3 3/4") x 70mm (2 3/4")
    Equipment: 500gr @ 250fps, Ro<10
```
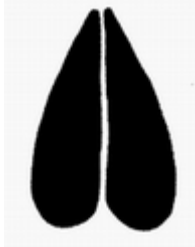

Further Reading: Cleve Cheney, **AB&A**, Aug 2007, p8, *"Hunting Gemsbok"*

5.2.16   Giraffe (*Giraffa camelopardalis giraffa*)
female:category #4, male: category #5

    Average Mass: 600-1400, 55, 330-770
    Temperament: Reasonably calm - Cautious
    Average Shoulder Height: 5 -6 m (16 - 19 ft)
    Rowland Ward: nc
    SCI: nc
    Track: 190mm (7") x 150mm (6")
        Equipment: 900gr @ 210fps, Ro<5

Further Reading: Gideon Van Niekerk, **AB&A**, Jul 2006, p30, *"My Giraffe"*

5.2.17   Grey Rhebok (*Palea capreolus*)
category #1


```
Average Mass:    25
Temperament: nervous
Average Shoulder Height:    81 cm (32")
Rowland Ward:   20.01 cm (7 7/8 ")
SCI:    18 Points
Track: 64mm (2 1/2") x 41mm (1 5/8")
     Equipment: 350gr @ 250fps, Ro<12
```

5.2.18   Grysbbok (*Raphicerus melanotis*)
category #1


```
    Average Mass:    8-14, 55, 4-8
    Temperament:
    Average Shoulder Height:    54 cm (21")
    Rowland Ward:   7.62 cm (3")
    SCI:    7 Points
    Track: 32mm (1 3/4") x 19mm (3/4")
        Equipment: 350gr @ 250fps, Ro<12
```

Further Reading: Cleve Cheney, **AB&A**, Nov 2006, p8, *"Hunting Cape Grysbok"*
Engee Potgieter, **AB&A**, Nov 2006, p25, *"Bowhunting the Cape Grysbok"*

5.2.19 Hartebees (*Alcelaphus buselaphus*)
category #2


```
Average Mass:   160-182, 55, 88-100
Temperament: Cautious
Average Shoulder Height:   124 cm (49")
Rowland Ward:   58.42 cm (23")
SCI:   62 Points
Track: 98mm (3 7/8") x 67mm (2 5/8")
     Equipment: 450gr @ 250fps, Ro<12
```


Further Reading: Cleve Cheney, **AB&A**, Aug 2008, p8 (Red)
Cleve Cheney, **AB&A**, Mar 2007, p8, *"Hunting Lichtenstein Hartbees"*

5.2.20 Hippo (*Hippopotamus amphibius*)
category #6


```
Average Mass:   2000
Temperament: Caution to nervous
Average Shoulder Height:    150 cm (60")
Rowland Ward:   75.89 cm (29 7/9")
SCI:    50 Points
Track: 254mm (10 ") x 254mm (10 ")
     Equipment: 1000gr @ 205fps, Ro<5
```


Further Reading: Fritz Rabe, **AB&A**, Mar 2009, p17

5.2.21   Hyaena (*Crocuta crocuta*)
category #2


```
Average Mass:   70
Temperament: Reasonably calm
Average Shoulder Height:    80 cm (31")
Rowland Ward: -----
SCI:    15 Points
Track: 110mm (4") x 110mm (4")
     Equipment: 350gr @ 250fps, Ro<12
```


Further Reading: Cleve Cheney, **AB&A,** Sep 2009, p8, *"Hunting Hyena"*

5.2.22   Impala/Rooibok (*Aepyceros melampus melampus*)
category #1


```
Average Mass:   39-80, 58, 22-46
Temperament: Cautious
Average Shoulder Height:   90 cm (36")
Rowland Ward:   60.02 cm (23 5/8")
SCI:    54 Points
Track: 60mm (2 3/8") x 41mm (1 5/8")
      Equipment: 350gr @ 275fps, Ro<12
```
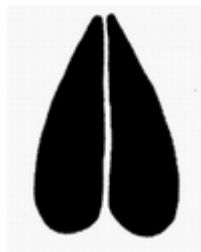
Further Reading: Cleve Cheney, **AB**, Nov/Dec 2000, p8, *"Bowhunting the Impala"*
Cleve Cheney, **AB&A**, Jul 2007, p8, *"Hunting Impala"*
Eddie Muller, **AB&A**, Jul 2007, p19, *"Impala Hunt at Elandskloof"*
Gerhard Delport, **AB&A**, Mar 2009, p34

5.2.23   Jackals

category #1


```
Average Mass:   4 - 8kg
Temperament: Cautious
Average Shoulder Height:    30 cm (12")
Rowland Ward:
SCI:
Track:
      Equipment: 350gr @ 250fps, Ro<12
```

Further Reading: Cleve Cheney, **AB&A**, Apr 2007, p6, *"Hunting Black Back Jackal"*

5.2.24 Klipspringer (*Oreotragus oreotragus*)

category #1


```
Average Mass:   11-16, 55, 6-9
Average Shoulder Height:    53 cm (21")
Rowland Ward:   10.49 cm (4 1/8 ")
SCI:    11 Points
Track: 22mm (7/8") x 13mm (1/2")
    Equipment: 350gr @ 250fps, Ro<12
```

5.2.25   Kudu (*Tragelaphus strepsiceros strepsiceros*)

female category #2, male category #3



Average Mass: 150-300, 57, 86-172
Temperament: Cautious
Average Shoulder Height: 150 cm (59")
Rowland Ward: 136.85 cm (53 7/8 ")
SCI: 121 Points
Track: 111mm (4 3/8") x 51mm (2")
     Equipment: 500gr @ 250fps, Ro<10

Further Reading: Cleve Cheney, **AB&A**, Sep 2006, p8, *"Hunting Kudu"*

5.2.26   Leopard (*Panthera pardus*)
category #3


```
Average Mass:   82
Temperament: Reasonably calm
Average Shoulder Height:    71 cm (28")
Rowland Ward:   39.06 cm (15 3/8")
SCI:    14 Points
Track:108mm (4 1/4") x 108mm (4 1/4")
     Equipment: 500gr @ 250fps, Ro<12
```

5.2.27   Lion (*Panthera leo*)
category #3


```
Average Mass:   210
Temperament: Reasonably calm
Average Shoulder Height:   106 cm (42")
Rowland Ward:   60.96 cm (24 ")
SCI:    23 Points
Track: 146mm (5 3/4") x 127mm (5")
     Equipment: 500gr @ 250fps, Ro<12
```


Further Reading: George Tsaparis, **AB**, Jan/Feb 2001, p22, *"Lion Hunt"*
Smit Craill, **AB&A**, Feb 2008, p50, *"Om 'n leeu met 'n boog te jag"*

5.2.28   Nyala (*Tragelaphus angasii*)
female category #1, bull category #2


```
Average Mass:   90-136, 55, 50-75
Temperament: Cautious
Average Shoulder Height:    112 cm (44")
Rowland Ward:   68.58 cm (27")
SCI:    63 Points
Track: 60mm (2 3/8") x 41mm (1 5/8 ")
      Equipment: 450gr @ 250fps, Ro<12
```

5.2.29 Oribi (*Ourebia ourebia*)
category #1


```
Average Mass:   14-20, 55, 8-11
Temperament:
Average Shoulder Height:   58 cm (23")
Rowland Ward:   14.93 cm (5 7/8 ")
SCI:   13 Points
Track: 35mm (1 3/8") x 19mm (3/4")
    Equipment: 350gr @ 250fps, Ro<12
```

5.2.30 Ostrich (*Stuthio camelus*)
category #2


```
Average Mass:
Temperament:
Average Shoulder Height:
Rowland Ward:
SCI:
Track:
     Equipment: 400gr @ 250fps, Ro<12
```


Further Reading: Cleve Cheney, **AB&A**, Feb 2008, p8, *"Hunting Ostrich"*

5.2.31　Porcupine ()
category #1


```
Average Mass:   10-24kg
Temperament:
Average Shoulder Height:   10 - 15 cm (6")
Rowland Ward:
SCI:
Track:
     Equipment: 350gr @ 250fps, Ro<12
```

Further Reading: Cleve Cheney, **AB&A**, Jan 2008, p8, *"Hunting Porcupine"*

5.2.32 Puku (*Kobus vardonii*)

category #2


```
Average Mass:    62-74kg
Temperament:
Average Shoulder Height:    80 cm (31")
Record:   56,2 cm
SCI:
Track:
     Equipment: 450gr @ 250fps, Ro<12
```

Further Reading: Cleve Cheney, **AB&A**, Jul 2006, p8, *"Hunting the Puku"*

5.2.33 Reedbuck (*Redunca arundinum*)

category #2


```
Average Mass:   50-80, 55, 28-44
Temperament: nervous
Average Shoulder Height:   91.44 cm (36")
Rowland Ward:   35.56 cm (14")
SCI:     21 Points
Track: 64mm (2 1/2") x 41mm (1 5/8")
     Equipment: 450gr @ 250fps, Ro<12
```

5.2.34   Rhino (*Ceratotherium simum simum*)
category #6


```
Average Mass:   2150
Temperament:
White: Reasonably calm; Black: nervous
Average Shoulder Height: 170cm (67")
Rowland Ward:  71.12cm (28")
SCI:   70 Points
Track: 279mm (11") x 229mm (9")
     Equipment: 1200gr @ 200fps, Ro<5
```


Further Reading: Cleve Cheney, **AB&A**, Apr 2006, p8, *"Hunting White Rhino"*

5.2.35   Roan Antelope / Bastergemsbok   (*Hippotragus equinus equinus*)

category #3


```
    Average Mass:   227-272, 55, 125-150
    Temperament: Cautious
    Average Shoulder Height:    143 cm (56")
    Rowland Ward:   68.58 cm (27")
    SCI:    68 Points
    Track: 121mm (4 3/4") x 89mm (3 1/2")
         Equipment: 600gr @ 250fps, Ro<10
```


Further Reading: Cleve Cheney, **AB&A**, Jan 2009, p8

5.2.36   Sable (*Hippotragus niger niger*)
category #3


```
Average Mass:   180-230, 55, 100-127
Temperament: Cautious
Average Shoulder Height:    140 cm (55")
Rowland Ward:   106.37 cm (41 7/8 ")
SCI:    100 Points
Track: 114mm (4 1/2") x 76mm (3")
     Equipment: 600gr @ 250fps, Ro<10
```


Further Reading: Cleve Cheney, **AB&A**, Nov 2007, p8, *"Hunting Sable"*
Carl Hager, **AB&A**, Nov 2007, p13, *"Fable of a Sable"*

5.2.37   Sitatunga / Waterkoedoe (*Tragelaphus spekei*)
category #2


```
    Average Mass:   55-115kg
    Temperament:
    Average Shoulder Height:    75-125 cm (29")
    Record:   92.4 cm
    SCI:
    Track:
        Equipment: 400gr @ 250fps, Ro<12
```

Further Reading: Cleve Cheney, **AB&A**, Jun 2007, p8, *"Hunting Sitatunga"*

5.2.38   Soenie/Suni (*Neotragus moschatus*)
category #1


```
    Average Mass:    5kg
    Temperament:
    Average Shoulder Height:    35 cm (14")
    Rowland Ward:
    SCI:
    Track:
        Equipment: 350gr @ 250fps, Ro<12
```

Further Reading: Cleve Cheney, **AB&A**, Oct 2006, p8, *"Hunting Suni"*

5.2.39   Springbuck   (*Antidorcas marsupialis*)

category #2
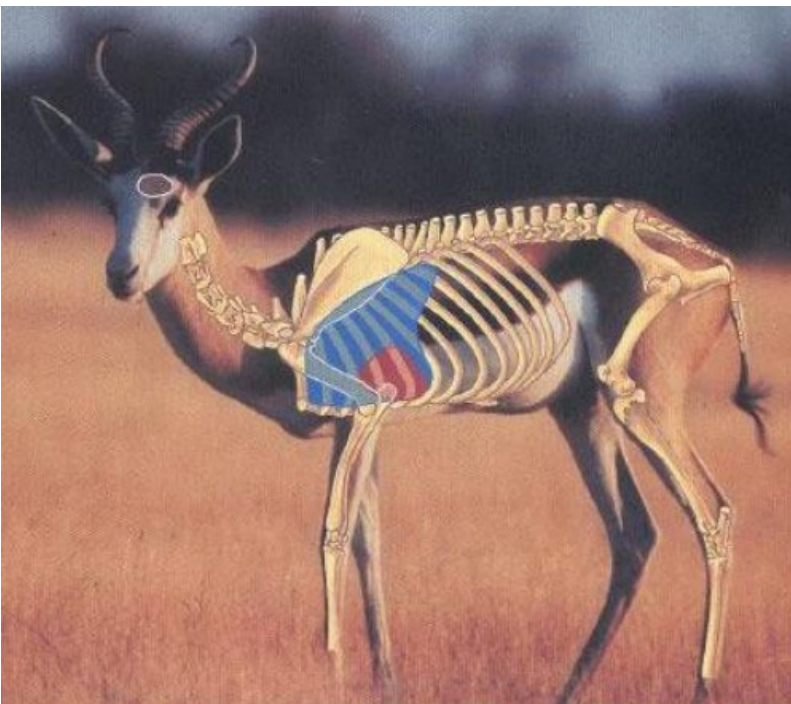

```
    Average Mass:   33-48, 51-58, 18-26
    Temperament: nervous
    Average Shoulder Height:    74 cm (29")
    Rowland Ward:   35.56 cm (14")
    SCI:    30 Points
    Track: 51mm (2") x 35mm (1 3/8")
        Equipment: 350gr @ 275fps, Ro<12
```
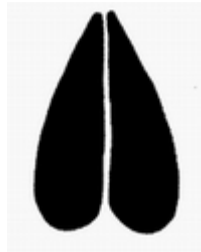

Further Reading: Cleve Cheney, **AB&A**, May 2008, p8, *"Hunting Springbuck"*
Frank Berbuir, **AB&A**, May 2008, p27, *"Springbuck with bow and arrow"*

5.2.40   Steenbok   (*Raphicerus campestris*)
category #1


```
Average Mass:    9-14, 55, 5-8
Temperament: Cautious
Average Shoulder Height:    52 cm (20")
Rowland Ward:   11.43 cm (4 1/2")
SCI:    11 Points
Track: 32mm (1 1/4") x 19mm (1 3/4")
     Equipment: 350gr @ 250fps, Ro<12
```

5.2.41 Tsessebe (also Topi)(*Damaliscus lunatus lunatus*)

category #2


```
    Average Mass:   126 - 140 kg
    Temperament: Cautious
    Average Shoulder Height:    120 cm (47")
    Record:  46.99 cm
    SCI:
    Track:
        Equipment: 450gr @ 250fps, Ro<12
```

Further Reading: Cleve Cheney, **AB&A**, Mar 2009, p8

5.2.42 Warthog (*Phacochoerus africanus*)

category #2


```
Average Mass:   80
Temperament: Cautious
Average Shoulder Height:    70 cm (28")
Rowland Ward:   33.02 cm (13")
SCI:    30 Points
Track: 51mm (2") x 44mm (1 3/4")
    Equipment: 450gr @ 250fps, Ro<12
```

5.2.43 Waterbuck (*Kobus ellipsiprymnus*)
category #3
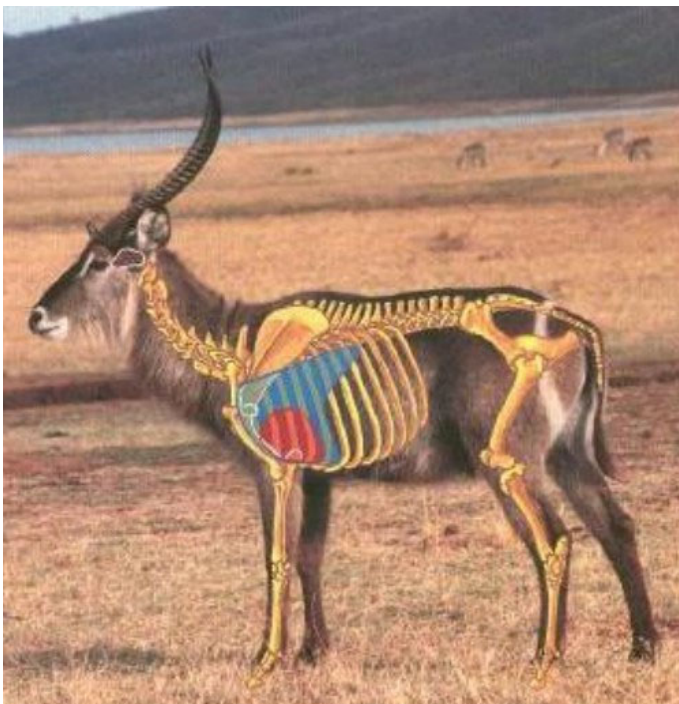

```
Average Mass:   240-270, 55, 112-150
Temperament: Cautious
Average Shoulder Height:    127 cm (50")
Rowland Ward:   71.12 cm (28")
SCI:    70 Points
Track: 51mm (2") x 44mm (1 3/4")
     Equipment: 500gr @ 250fps, Ro<10
```
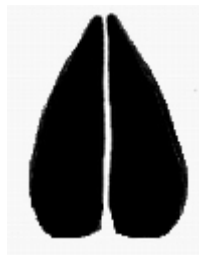

Further Reading: Cleve Cheney, **AB&A**, Oct 2007, p8, *"Hunting Waterbuck"*
Adrian De Villiers, **AB&A**, Oct 2007, p13, *"Defassa Waterbuck"*

5.2.44   Wild Boar (*Sus scrofa barbarus*)
category #5

Note: The reason for its high category is its grizzle pad, a collagen shield that protects the vitals.
  Average Mass: 50 to 350
     (big difference in sub-species)
  Temperament: nervous
  Average Shoulder Height: 91 cm (36")
  Rowland Ward:
  SCI:
  Track:
       Equipment: 800gr @ 250fps, Ro<5

Further Reading: Engee Potgieter, **AB&A**, Dec 2007, p13, *"An Eurasian Wild Boar Hunt"*

5.2.45   Zebra (*Equus quagga antiquorum*)
category #3


```
    Average Mass:   270-350, 55, 150-200
    Temperament: Reasonably calm
    Average Shoulder Height:    130 cm (51")
    Track: 127mm (5") x 102mm (4")
         Equipment: 500gr @ 250fps, Ro<8
```

Further Reading: Cleve Cheney, **AB&A**, Apr 2008, p8, *"Hunting Burchell's Zebra"*
Cleve Cheney, **AB&A**, Sep 2009, p46, *"Tracking Zebra"*
Cleve Cheney, **AB&A**, Aug 2006, p8, *"Hunting the Hartman's Zebra"*

5.3 Gender Recognition Using Horns

The females of the following animals:

does NOT have horns: **DOES have horns:**

does NOT have horns:	DOES have horns:
Impala	Springbok
Soenie	Eland
Dik dik	Buffel
Klipspringer	Blou/Rooi duiker
Oorbietjie	Bastergemsbok (Roan)
Steenbok	Swartwitpens (Sable)
Grysbok	Gemsbok (Oryx)
Bosbok	Rooihartbees
Njala	Swart/Blou-wildebees
Koedoe	Blesbok
Grysduiker	Bontebok
Vaalribbok	Basterhartbees
Rooiribbok	
Rietbok	
Waterbok	

Further Reading: Fritz Rabe, **AB&A**, Dec 2008, p25, *"The Tiny Ten"*
Fritz Rabe, **AB&A**, Sep/Oct/Nov 2008, p17, *"Dangerous Game"*

5.4 Synopsis on legislation in other Southern African Countries

5.4.1 Namibia

Namibia have a recent legislation on Bowhunting, all antelopes can be hunted with bow and arrow. The guide must have a special permit to accompany bow hunters. Just as RSA, Namibia has chosen the arrows kinetic energy as a rule for the various sizes of game. (we expanded it to include mass and velocity)

```
Category        : Small antelopes ex. Blesbuck
mass(gr)        : 300
velocity(fps)   : 200
Kinetic Energy  : 25
momentum%       : 27

Category        : Midsize antelopes ex. Kudu, Warthog
mass(gr)        : 350
velocity(fps)   : 230
Kinetic Energy  : 40
momentum%       : 36

Category        : Large antelopes ex. Eland, Gemsbok
mass(gr)        : 500
velocity(fps)   : 235
Kinetic Energy  : 60
momentum%       : 52
```

5.4.2   Botswana

In 1995 was the first modern bow hunts allowed. Hunting with bow and arrow is only allowed on plains game.
Minimum (400gr@240fps) 50FtLbs 68 Joule for the following game: Bushbuck, Duiker, Reedbuck, Red Lechwe, Impala, Oribi, Wildebeest, Zebra, Tsessebe, Kudu, Sable, Hartebeest, Gemsbok.

5.4.3   Zimbabwe

In Zimbabwe Bowhunting has been legal with special regulation since 1989. The legislation has recently been changed and from 1999 according to Park and Wildlife General Amendment Regulation no 3 i.e. Bowhunting is allowed on "Alienated land" i.e. private and federal land excluding the concessions bordering the Zambezi or other areas were a concession is in effect.

Category B-D including lion and leopard Least pull is 25kg or 55 pound
Larger antelope Minimum pull 35Kg or 77 pound min arrow weight 615gr (40 grams)
Giraffe and Eland Minimum pull 35Kg or 77 pound min arrow weight 700gr (45 grams)
All animal, except Rhino, can be hunted with bow and arrow. The big game species require permits.

5.4.4   Some American Guidelines

Small Game (rabbit, groundhog, etc.)
mass(gr)   : 300
velocity(fps) : 200
Kinetic Energy : 25
Momentum%   : 27

Medium Game (deer, antelope, etc.)
mass(gr)   : 350
velocity(fps) : 230
Kinetic Energy : 40
Momentum%   : 36

Large Game (elk, black bear, wild boar, etc.)
mass(gr)   : 500
velocity(fps) : 240
Kinetic Energy : 65
Momentum%   : 53

Toughest Game (Grizzly, etc.)
mass(gr)   : 500
velocity(fps) : 240
Kinetic Energy : 65
Momentum%   : 53

6   Assessing the Bowhunter's proficiency

6.1   Bowhunting Education and Certification Objectives

The objectives of this book are:

- To provide an excellent and responsive skills development service to bowhunting and bowhunting ethics in general.
- To enhance a culture of self regulation, and to instill in the reader a conscious decision to take responsibility for his own personal growth with regard to ethical bow hunting, in order to determine his strengths and weaknesses coupled with ability.
- To create an in-depth equipment knowledge and hunting competence to enable the reader to identify skills and areas of development appropriate to his/her current and future shooting, archery and hunting abilities, which includes understanding and knowledge.
- To provide the reader with specific outcomes and a range of learning with regard to knowledge and understanding.
- To foster ethical and responsible actions while hunting. To improve competency levels in ethical standards through reading this to prevent unethical and immoral acts.
- To create a culture of bow hunters as responsible and conscientious people to act responsibly towards people, the wildlife and environment in which they shoot and hunt.

6.2   General suggestions on the certification process

The Assessor should ideally make use of a projector and notebook/laptop computer, since there are numerous colour pictures. The questionnaire should also be printed in colour.

The assessment should be done in the following order:
1. Grouping measurement
2. Discussion and Q&A on all aspects
3. Theoretical test
4. Practical Shot Placement test

In order to do the certification, the hunter requires the following:
- A bow, and at least 3 arrows with broadheads
- A rangefinder (optional)
- A pen and calculator
- A ID photograph
- Clothed in hunting gear. Practical assessment will be done in full hunting gear.

6.3   Suggestions for placing the 3D targets

For the purpose of standardization, the following rules for the placing of the

targets should be followed:
1. It should include two of the following animals: warthog, impala, blesbok, gemsbok, lion.

2. If 2 of each are not available, placing 2 directional pegs for one animal is suggested. These pegs only show the direction the shot must be taken at, and the peg can be at a convenient distance. The shooting distance will be on the maximum as calculated during the theoretical test. Please take note that this can be as far as 60Y.
3. Two unethical situations should be set up. These could involve:
   multiple animals - with target in front of another,
   obstructions (grass/twigs),
   animal standing at very oblique angle.
4. Two targets must be uphill shots, at least 10 degrees.
5. Two targets must be downhill shots, at least 10 degrees.
6. At least one target each where the hunter have to sit on the ground, and kneel to shoot.

6.4 Recommendations in relation to accuracy and its assessment

In assessing accuracy there are more ideas than hunters. If we can agree on the basic outline of accuracy then the particular method is not of great importance. There are three aspects of what we generally call accuracy. The first is on line with the statistical meaning thereof, how close to the centre of the target you shoot.
The second is consistency or precision, which involves grouping sizes - how close are your shots to each other. The third, shot placement is of course where the bowhunter decided to aim at.

When defining a hunter's accuracy, the parameters within which assessment is done are the number of shots and the distance to the target.   It is statistically advantageous to do the assessment with as many shots as possible. However in any probabilistic occurrence, the more shots used, the larger the grouping will become. So in order to standardize an assessment, we need to either accept arbitrary parameters, or be able to remove its effect. For example, the effect of the distance used in assessment can be largely removed by dividing with it, since grouping size is proportional to distance. The effect of the number of shots is not that easy.

Using an average distance of each shot from the centre, or from each other, involves many and physically difficult measurements. The simplest measurement involves wrapping a tape measure around all the arrow shafts. This way you measure the smallest polygon's circumference that would cover all the shots. It is a fairly accurate measurement in that it measures circumference, which is generally about 3x larger than the diameter of the smallest circle around them. This measurement in effect ignores all the good shots, and takes all the worst shots into account. You cannot "make up" for a few bad shots, by doing lots of good ones.

Compensating for the number of shots taken in the assessment, on average, the circumference grows after 500 shots to about twice that of the first 6 shots. It is therefore that we proposed the safety factor that uses double the grouping size.

The proposed accuracy assessment involves 2 tests. **The first test would be 6 shots at a distance comfortable to the hunter, in a "broadhead butt", using the intended hunting points.**

(Since the hunter may not have 6 arrows, or may not want to run the risk of damaging his hunting arrows, you can use markers for each shot, a short piece of shaft material comes to mind.) The circumference is divided with 3 (p is about 3) to calculate diameter. The accuracy is then expressed in terms of the grouping diameter divided by the distance of assessment. This results in units for the value of inches per yard, or mm/m.

The second test of accuracy is done only after the theoretical section of the

program, since information calculated during this section is needed for the 2nd practical test.

The second phase of the test is the theoretical discussion and "open book" test.
Each hunter should be encouraged to make their own decisions, but discussion during the test is not prohibited.
The objectives of this phase are to educate firstly, and then test the hunter on:
   1) Identification of species
   2) Classification of animals into categories
   3) Compensating for angled shots
   4) Assessment of the temperament of the animal
   5) Identification of Gender
   6) Assessment of ethical situation
   7) Shot Placement
   8) Evaluation of hunting equipment re suitability
   9) Calculating maximum ethical hunting distances
   10) Showing general knowledge on bowhunting technique and practice

Each objective is to be scored separately. A score sheet is provided for this.
Objectives 1 to 6 are tested in Part 1 of the test, answers (a) to (f) respectively.
Objective 7 is scored on where the aiming point is indicated on the image of the animal.
Objective 8 is scored on the first subsection of Part B.
Objective 9 is scored on the second subsection of Part B.
Objective 10 is scored on Part C.

The tests are to be marked by collecting all the papers, and then randomly distributing them among all the participants. The marking is then done as a group effort, with full discussion of all answers.

The third phase involves a practical accuracy and shot placement assessment.
This involves 10 shots at 3D targets in the field, set up using a particular colour stake indicating direction of the shot. The distance shot at should be the <u>maximum distance</u> as calculated by the hunter during the test, for this animal. This maximum yardage will be based on the first test's accuracy alone, and do not take reaction time into account.

The hunter gets only one shot at each target. This is the closest we can get to put some pressure on the hunter.

The bowhunter must:
1) Identify the species,
2) Measure the distance using a rangefinder
3) Discuss the shot placement and ethics of the shot and
4) If deciding to take the shot, do so.

The assessor should also discuss the 3D position of vital organs.

If it is an ethical shot in relation to the hunter's set-up and ability, the shot is scored with 10 for hitting the vital area, and 0 for missing it. If the bowhunter decided not to take a shot even though it was ethical, it does not count towards the assessment.
If it is not an ethical shot, and is taken by the hunter, the shot is scored 0 irrespective of it hitting the vital area. If the hunter decided not to take an unethical shot, a score of 10 is awarded. Making 5 errors out of 10 targets will result in 50% total score, or a probability of about 50% of wounding at the proposed hunting distances.

The fourth phase of the BProC is a requirement to "stay in practice", and involves a hunter to do at least three SABA hunting point competitions per year.

It is proposed that the above scores on accuracy (in the form of max distances per category), shot placement and accuracy at SABA competition, be printed on the bowhunting certificate. The purpose of this assessment should not provide a "pass" result, but rather a record with an accuracy evaluation for the farmer and hunter. After each SABA competition the hunter receives a printed certificate with these scores and the scores for the last 3 competitions on it as well. The dates of the assessments should also be printed. Of course not all 3 of these competition scores are available after the first competition, and

should print "unavailable". Only competitions done within the last 6 months will be printed.

When presenting the certificate at a venue with the purpose of hunting, the PH/owner/manager (called PH from here on) can then in addition to any other on site assessment, make a more informed decision on how to present the hunt to the hunter.

All hunts, and animals shot at, should be logged by the PH in the hunter's log, with a copy of the log page sent to SABA by the PH. This is not with the intention to police the hunter, but to keep statistics of all hunts, and to verify the hunting results with the proficiency evaluation. For example if hunters have no problem in shot placement in the field, while this test show's they should have had a problem, the test is too stringent, and should be altered.

The hunter should get a printed and signed certificate, and a badge for apparel, indicating they've done the BProC, and a CDRom with this manual.

The Bow Hunters Oath:
"I, as a bow hunter, have a responsibility to nature and the sport of bow hunting to practice ethical harvests with minimum suffering."

Quick harvests and easy game recovery can be obtained with accurate shot placement.

The three main ingredients of a quick harvest are knowledge of how a bow kills game, shooting only within one's own ability, and knowing the game animal's internal anatomy. The future of bow hunting and a hunter's own self-respect depends on his or her ability to efficiently and ethically hunt.

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Herman Brand, **AB&A**, Nov 2007, p52, *"Feite en Opinies"*
John Dudley, **AB&A**, Nov 2007, p30, *"Walk-back tuning with broadheads"*
Seppie Celliers, **AB&A**, Nov 2007, p55, *"Stel jagpunte in - maklik"*
Cleve Cheney, **AB&A**, Nov 2007, p20, *"Fooling Animal eyes - Part 2"*

Bow Hunting Logbook #........

Hunter			Farm		
Name			Name		
Address			Province/area		
			Exemption Number		
ID number			Farm owner		
Phone/Cell			Phone/Cell		
Date of Hunt .... to			Professional Hunter		Total

Expenses	
Day Fee	
Animals	
Travel	
Other	
Total	

Bows:

	Manufacturer	Model	Draw weight
#1			
#2			
#3			

Arrows:

	Description	Total weight	Speed	Spine	Broadhead weight	PA
#1						
#2						
#3						

Animals shot:

Species	Animal				Shot					
	Sex	Carcass Weight	Price	Trophy Size	Bow #	Arrow #	Distance	Angle	Placement	Recovery Distance

Hunter's Notes:

Farm Owner's Notes:

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In memoriam...

BURGERT JOUBERT
Gebore: 1977-10-03
Oorlede: 2010-09-04

BOER