The Case for Straight Fletching

By Stephen Graf

It's surprising how often my intuition is wrong, yet every time I have an opportunity to trust it, I jump at the chance to do so. Affixing fletching in a helical curve to my arrow shafts is a case in point, another lesson my longbow and arrows have taught me in a long string of lessons that never seems to end. Is helical fletching really the best option?

Many thoughtful people have taken the time to record their experiences and thoughts based on reason and evidence, including three people who, through their patience and repetition, have finally drummed it into my head that maybe straight fletching is better.

Hugh Soar, in his book *Secrets of the English War Bow*, says that helical fletching "increases drag and thus decreases velocity. Distance is sacrificed for potentially greater accuracy... Helical fletching was consigned to the woodshed of history, where, with occasional forays into the light, it languishes to this day." He does mention in another passage that some of us on the other side of the pond haven't yet given up on them.

C. N. Hickman was a well-regarded physicist who wrote extensively on archery when he wasn't calculating projectile trajectories for the war department. In an article titled "Dispersion of Arrows" published in the peer reviewed Journal of Applied Physics, Hickman wrote: "Many archers think that the dispersion of an arrow could be improved by stabilizing it with spin. In the first place such a long projectile cannot be stabilized by spin and in the next place fin stabilized projectiles are just as accurate as those stabilized by spin."

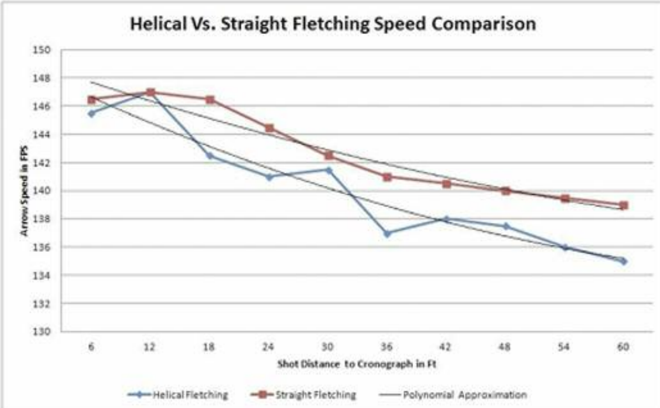
Finally, Robert Elmer, one of my favorite archery writers, touches on the topic in his book *Target Archery*: "When Ascham hinted that one of the knotty problems of his day was whether a feather should be 'set on streight or somewhat bowyng', he touched on a subject which has never ceased to be debated. Because all projectiles of firearms hold a more accurate course if they revolve at high speed it is natural to suppose that arrows will do the same. The comparison is faulty..."

Straight fletched arrow the author used for the test.

Since bullets and arrows are both projectiles, it is "natural to suppose" (to use Elmer's words) that the same physical rules apply to both. If we look just a bit deeper, we will see that the only characteristic that arrows and bullets share is their purpose. An arrow has much more in common with a rocket than with a bullet. Let me explain.

First, let's consider what gives a bullet its stability and then compare that to an arrow. The rifling of a gun barrel imparts considerable rotational momentum to a bullet. Surprisingly, rotational momentum alone cannot be counted on directly to provide the bullet its stability. The forward velocity also plays a part, as does the length to diameter ratio of the bullet and its density. The faster a bullet is travelling, the more unstable it is, and the faster it needs to rotate to compensate. Additionally, the longer a bullet is (compared to its diameter) the more unstable it is. Physicists refer to this relationship as "gyroscopic stability." If you lick your pencil and struggle through the math, you will find that (as Hickman alludes) an arrow would have to spin millions of revolutions per second (because of its extreme length to diameter ratio and low density) to achieve the same gyroscopic stability as a bullet. The fletching would blow off an arrow long before it achieved a stabilizing rotational momentum.

Secondly, let's consider what (besides the now dubious



spin) gives an arrow its stability. An arrow has a few qualities in its favor: it is long and thin; it has a dynamic steering system that controls it during its entire flight (unlike a bullet that is on its own once it leaves the barrel); and it has a heavy point causing the center of mass to be located toward the front of the arrow instead of in the middle. All these factors, without rotation, contribute to the stabilization of the arrow and make it more like a rocket than a bullet.

There have been several studies done showing that where an arrow's center of mass lies along its longitudinal axis affects its flight distance (Hickman: The Center of Gravity of an Arrow and its Flight, *Archery Review*, Feb. 1934). More recently other studies, including those done by Dr. Ed Ashby which are posted on the **TBM** website, corroborate the results Hickman published.

So, the long length of the arrow (as compared to its diameter), along with the heavy mass of the point, work together to move the center of mass toward the tip and away from the fletching. All archers who spend any time tuning an arrow soon discover that the balance point of an arrow should be at least 10% in front of the geometrical center (toward the tip) of the arrow. We call this 10% FOC.

What is true for arrows is true for rockets, which are designed so that the heavier tanks (oxidizer) are put toward the tip of the rocket and the lighter tanks (fuel) are put toward the engines. This assures that the center of mass of the rocket is toward the tip.

Feathers provide steering control throughout the flight of the arrow. When the arrow gets off axis (the longitudinal axis of arrow is not in alignment with flight path) air pressure and drag on the arrow increases on the leading side and pushes the arrow back toward correct alignment.

Again, we see that what is true for arrows is also true for rockets. Rockets are designed with control fins at their rear. These fins have, over time, become less important as the technology for gimbaling the engines (pointing rocket engines to control direction) has improved. Nevertheless, fins still play an important part in guiding rockets.

Finally, have you ever seen a rocket do anything but fly straight and true (without rotation) into space? I can't imagine finding any astronauts willing to ride a rotating rocket into space. Just the idea makes me queasy.

So, I've made the case that straight fletching is all that is needed to cause an arrow to fly well. What happens when you stick a broadhead on the front of that arrow? Won't it cause mischief to the arrow's flight? Isn't rotation required to stabilize a broadhead arrow so that the broadhead doesn't cause the arrow to plane off in one direction or another?

I have found that even the straightest feathers will induce a considerable amount of rotation in the arrow. This is caused by the difference in roughness between the two sides of a feather. The airflow over the rougher side of the feather will be more turbulent than it is over the smooth side of the feather. This difference in airflow will induce a pressure difference between the two sides of the feather, and thus spin. My straight fletched arrows, equipped with field points or broadheads, fly to the same mark.

These factors explain why helical fletching is not necessary to stable flight of an arrow. The thoughtful reader may still ask, "Why should I bother switching to straight fletching? What is to be gained by making the change?" I will attempt to explain what, based on my experience, makes straight fletching better and why one should consider shooting arrows so constructed.

Straight mounted feathers last longer than helical mounted feathers, because they are under less stress. I have found that the barbs and barbules stay together better and for much longer on straight feathers. This effect is so pronounced that it is reason enough for me to use straight mounted feathers.

Straight mounted feathers lie on the shaft better and don't lift off as easily as helical mounted feathers. I use tape to affix my feathers and find that the tape can come loose on hot and humid days with helical feathers. I have not had that problem since I switched to straight mounted feathers. Straight mounted feathers allow the use of the same fletching jig to mount both left wing and right wing feathers. I make my own fletching and have always felt bad that I couldn't use of the right wing of the turkey. I ended up giving a lot of those wings away. Now, I can use both wing feathers (not on the same arrow, of course). My quiver is full of arrows fletched with either wing, and they all fly the same.

Arrows fletched with straight mounted feathers experience less drag and thus lose less speed down range than the same arrow would with helical mounted feathers. This

The author's chronograph set up for testing the speed under controlled conditions of both helical and straight fletching.

means that the trajectory of the arrow is flatter, and there is more momentum in the arrow when it impacts the intended target. It is fair to ask how much the arrow slows down, and I have wondered that myself. So, I set up a chronograph and asked a friend (who is a better shot than I am) to shoot an arrow through the chronograph every two yards out to twenty yards. As you can see in the graph (page 55), the helical fletched arrow lost about four fps more than the straight fletched arrow. This may not seem like much, but if you shoot a faster bow the difference will be greater as the drag experienced by the arrow increases proportionally to the square of its speed.

While my friend is a good shot, he is limited to a bow with a draw weight in the thirties. If you pull more and have an arrow speed of around 165 fps, it will experience about 30% more drag. If you have an arrow speed of around 175 fps it will experience about 45% more drag. While I have no experimental evidence to prove it, I expect you would see a speed difference of at least fifteen fps at twenty yards between straight and helical fletching for those higher speed arrows (Is this my dread intuition at work again? Hmmm…)

We performed this experiment on a partly cloudy day, which can affect the accuracy of a chronograph. Additionally, we took only two readings at each distance. The data points on the graph represent the average of those two readings. These shortcomings, along with the human variability, account for the choppy nature of the curves. I think the polynomial approximation does a good job of illustrating the trend. Another point of interest is that we used the same arrow and feathers for both tests. After shooting the arrow with helical mounted feathers, we removed the feathers and remounted them straight.

Arrows with straight fletching make less noise as they fly through the air compared to arrows equipped with helical fletching. If you have a friend and a tree, you can prove this to yourself. Stand safely behind the tree while your friend shoots an arrow past you and into a target. You will hear the difference.

Finally, I believe (based on nothing but my casual experience) that a five-inch straight mounted feather gives better stability with less drag than a four-inch helical mounted feather.

Every time I discover that my intuition has missed the mark (much as when my arrow misses the mark), that miss becomes a learning experience for me. In both cases, I try to remember that my mistakes are opportunities for improvement. In the case of straight fletching, I learned that my intuition to use helical fletching was wrong. Straight fletching is more efficient, quieter, just as accurate, and more durable than helical fletching.

As the father of the steam locomotive, George Stephenson, famously said, "We learn wisdom from failure much more than from success. We often discover what will do, by finding out what will not do; and probably he who never made a mistake never made a discovery."

As a former NASA engineer, Stephen Graf is our only contributor who can honestly call himself a rocket scientist (even though T.J. and Don may occasionally try to get away with it). His book The American Longbow and Its Place in the Good Life *is available through most retail outlets. Stephen lives in rural North Carolina.*