## The Arrow Mystery

or: How I Learned to Stop Worrying and Love Arrow Spine

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## Background

I used to shoot archery when I was in middle and high-school, but haven't done much until recently when I decided to get back into it. A few years ago I got myself this beautiful 60 inch, 30 lb. recurve bow.



I shoot traditional archery. To me that means a recurve or longbow, wood arrows, no sights, clickers, wrist straps, counter weights, etc. Nothing fancy. I just throw a target up in the backyard and shoot with my kids.



Emmett enjoying his new back quiver

When I got my bow, I knew enough to pick the right spine for my arrows. (Spine is the measure of an arrow's flexibility. This is needed because the arrow needs to flex around the bow as it flies. I highly suggest googling "archer's paradox" for more info on this phenomenon.)

At my draw length, the draw weight is about 33 lbs. I measured that I need 28 inch long arrows. And I figured I would use 125 grain point weights since I heard that was common. I also heard that you should try a few different spines to find the best. So, I used this chart:

RECURVE/CENTER SHOT LONGBOW Finger Release ACTUAL PEAK BOW WEIGHT - Lbs.					Wood Arrow Length							LONGBOW / SELF BOW Finger Release ACTUAL PEAK BOW WEIGHT - Lbs. Drivel Weicht							
100 (grains)	125 (grains)	145 (grains)	160 (grains)	190 (grains)	22% 23" 23%	23% 24" 24%	24% 25" 25%	25% 26" 26%	26% 27" 27%	27% 28" 28%	28% 29" 29%	29% 30" 30%	30% 31" 31%	31% 32" 32%	100 (grains)	125 (grains)	145 (grains)	160 (grains)	190 (grains)
31-35	26-30	21-25	16-20								30-35	35-40	40-45	45-50					
36-40	31-35	26-30	21-25	16-20						30-35	35-40	40-45	45-50	50-55	41-45	36-40	31-35	26-30	
41-45	36-40	31-35	26-30	21-25					30-35	35-40	40-45	45-50	50-55	55-60	46-50	41-45	36-40	31-35	26-30
46-50	41-45	36-40	31-35	26-30				30-35	35-40	40-45	45-50	50-55	55-60	60-65	51-55	46-50	41-45	36-40	31-35
51-55	46-50	41-45	36-40	31-35			30-35	35-40	40-45	45-50	50-55	55-60	60-65	65-70	56-60	51-55	46-50	41-45	36-40
56-60	51-55	46-50	41-45	36-40		30-35	35-40	40-45	45-50	50-55	55-60	60-65	65-70	70-75	61-65	56-60	51-55	46-50	41-45
61-65	56-60	51-55	46-50	41-45	30-35	35-40	40-45	45-50	50-55	55-60	60-65	65-70	70-75	75-80	66-70	61-65	56-60	51-55	46-50
66-70	61-65	56-60	51-55	46-50	35-40	40-45	45-50	50-55	55-60	60-65	65-70	70-75	75-80	80-85	71-75	66-70	61-65	56-60	51-55
71-75	66-70	61-65	56-60	51-55	40-45	45-50	50-55	55-60	60-65	65-70	70-75	75-80	80-85	85-90	76-80	71-75	66-70	61-65	56-60
76-80	71-75	66-70	61-65	56-60	45-50	50-55	55-60	60-65	65-70	70-75	75-80	80-85	85-90	90-95	81-85	76-80	71-75	66-70	61-65
81-85	76-80	71-75	66-70	61-65	50-55	55-60	60-65	65-70	70-75	75-80	80-85	85-90	90-95	95-100	86-90	81-85	76-80	71-75	66-70
86-90	81-85	76-80	71-75	65-70	55-60	60-65	65-70	70-75	75-80	80-85	85-90	90-95	95-100	100+	91-95	86-90	81-85	76-80	71-75

I bought a set of red fletched 30-35 lb., and white fletched 35-40 lb. spined arrows from 3 Rivers Archery. I shot with them a bunch but could not tell much difference. Along the way, I got another set of arrows in a larger diameter, Blue Jay arrows also spined 30-35#, and could not tell any difference.

## The Mystery

The mystery began when I received a package with some of my old archery stuff which included a set of yellow crested arrows. Here are all four arrow types I have now:



I didn't have high hopes for the arrows because they were 3 inches longer than my current arrows, they were all banged up, and were probably not stored properly for nearly 2 decades.

But I shot them anyway and much to my surprise they shot great! So good that I decided I had to figure out what differentiated them from my current arrows.

The first thing I did was to quantify the "goodness" of each arrow type. I took 3 of each type and shot 4 flights at a target about 15 meters away. I shot the arrows in random order each flight, and tried not to think about which type of arrow I had nocked. I also tried to shoot as consistently as I could, not compensating one arrow to the next. Here are the results:



I was surprised there was so much difference between arrow types. The dot indicates the mean. Error bars are at 1 standard deviation. And the outer contour shows the (smoothed) histogram of the data. (It's called a violin plot for all you data geeks.)

Here are all the arrow stats:

Arrow Type	Shaft Dia. (in)	Length (in)	Spine (lb)	Point Weight (grains)	Fletching Length (in)
Yellow	.34375 (11/32)	31	?	125	5

Blue	.34375 (11/32)	28	30-35	125	4
Red	0.3125 (5/16)	28	30-35	125	5
White	0.3125 (5/16)	28	35-40	125	5

Nothing immediately stands out. Although it looks like arrows with a weaker spine (more flexible) might do a little better. But we obviously need to figure out the spine of the Yellow arrows. Spine testers are pretty expensive. But it isn't too hard to make a simple one yourself. I made this with two nails in a spare piece of wood.



Not shown: digital calipers used by hand to measure arrow deflection. FYI: For wood arrows, supported at 26 inches apart, 2 lbs hung at the center, the equation is:

26 / deflection inches = spine pounds

Here is the data I collected.



Before we dig into what this means, we can check the accuracy of my spine tester. White should have been in the 35-40 range and Red should have been in the 30-35 range. So those measured a little high. But Blue looks very close to what it should have been (30-35). So I have confidence that the Yellow arrows probably have a 40-45 spine.

As you can see, the Yellow arrows are actually \*stiffer\* than the rest. This result contradicts our earlier hypothesis about a weaker spine doing better. Plotting the arrow score vs spine doesn't show much correlation either. It seems to say that \*either\* a stiff spine or weak spine shoot better, which doesn't make sense.



In this plot, the dot is at the mean of the data, and the extents of the ellipse are one standard deviation in each axis.

After scratching my head a bit, and watching some YouTube videos on arrow spine, I realized that there is a difference between "static" spine (the measurement you get on a spine tester), and "dynamic" spine (how the arrow's inertia effects how willing it is to flex at shooting speeds). I learned that lengthening an arrow decreases its spine, and increasing point weight decreases the spine. Both of these make perfect intuitive sense. It is much easier to bend a long shaft, and even easier if it has a heavy weight on the end. I found a rule of thumb online that said an arrow's spine changes by 3-5 pounds per inch of shaft.

Furthermore, a careful reading of the arrow spine chart above from 3 Rivers Archery shows a difference of 5 pounds per inch of shaft. They also list a difference of 5 lbs. per point weight category. Although the difference in actual point weight between the categories varies between 15 and 30 grains.

So now if we adjust the spine of the Yellow arrows for their 3 additional inches, the score vs spine plot makes much more sense.



## Next steps

It is unclear if I really found the ideal dynamic spine for my bow. It would be interesting to continue to weaken the spine until the scores start to decrease. Furthermore, it would be interesting to see the tradeoff between static and dynamic spine, i.e. a short arrow with a flexible spine vs. a long arrow with a stiff spine. And the tradeoff between different dynamics compensations, i.e. a long stiff arrow with light point vs. short stiff arrow with heavy point. I'm sure much more seasoned and talented archers than me have answered these questions long ago (time to do some reading!), but there is nothing like getting your hands dirty with the actual data.

Next up, see Part 2 where I try different tip weights.