Free and bound unbraced back Long modes

This study starts with the observed frequency response of the same guitar back in free and bound to sides configurations. I didn't take pictures of every example, but there should be enough to make sense of. This study looks at the forms taken by the long pole modes and differences in frequency that correspond with different thicknesses and free or bound condition.

The monopole is not pictured. In free mode it is two fairly straight lines ¼ of the total length in from each end.

Free Monopole:
3.0mm/319g – 62Hz
2.5mm/256g – 51Hz
2.0mm/200g – 41Hz

Bound Monopole:

2.0mm/200g – 95Hz (main resonance peak)

The Free Long dipole pattern in Rosewood:
3.0mm/319g – 188Hz
2.5mm/256g – 155Hz
2.0mm/200g – 116Hz

The Bound Long dipole pattern, same piece

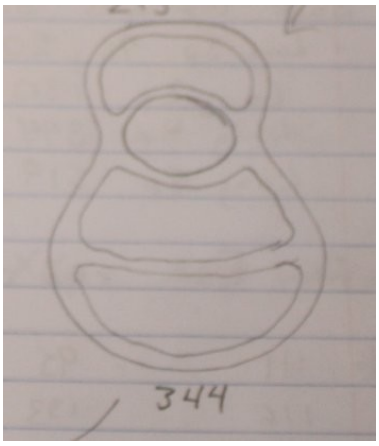
2.0mm/200g - 133Hz

The Free Long tripole in Rosewood:
3.0mm/319g – 356Hz
2.5mm/256g – 292Hz
2.0mm/200g – 226Hz

The Bound Long tripole, same piece:

2.0mm/200g - 215Hz

Free Long 4-pole in Rosewood:
2.0mm/200g – 373Hz



Bound Long 4-pole, same piece
2.0mm/200g - 344Hz

Long 5-pole in Rosewood:

2.0mm/200g – 549Hz

Not pictured, but more like the drawing above than the photo to the left.

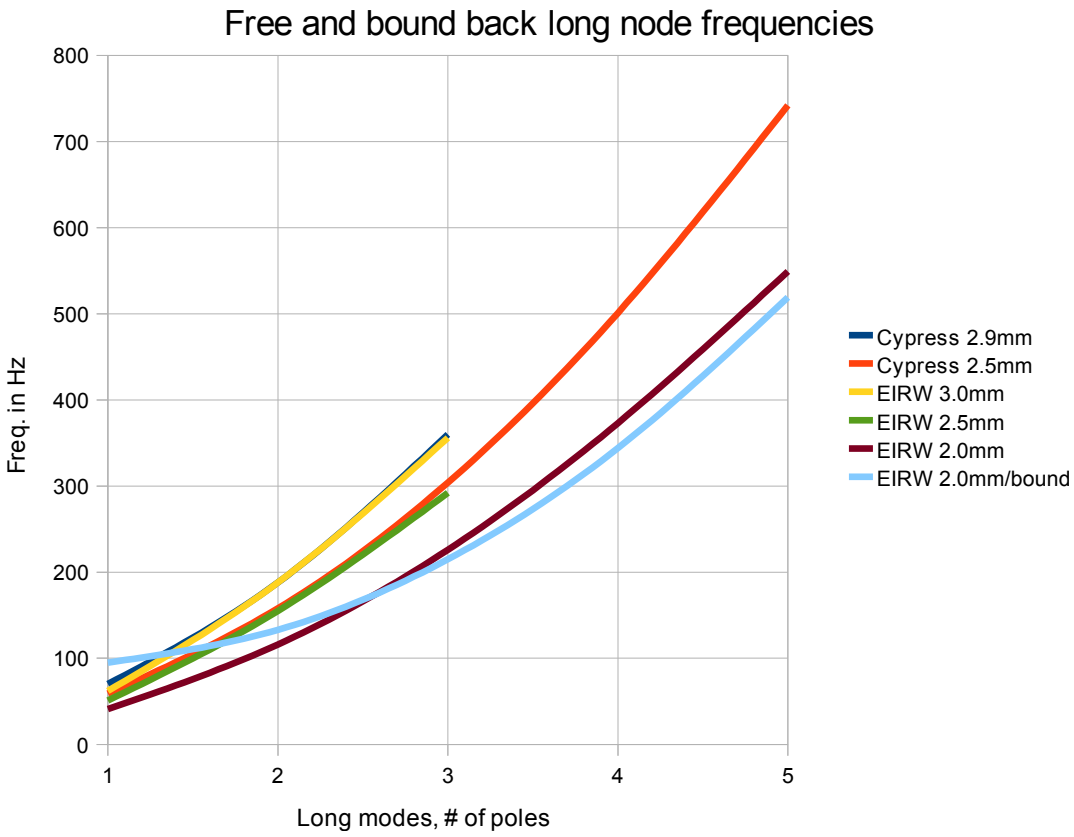
Bound Long 5-pole, same piece

2.0mm/200g - 519Hz

A summary chart follows. Note the ratios of the modes to each other. Given how different the woods are, these ratios are remarkably consistent. The cypress included in the data is from a previous study of which this one is a continuation.

		long poles as observed (free)								
Weight	**Wood/thickness**	**1**	**2**	**3**	**4**	5	**ratio 1 – 2**	**ratio 2 – 3**	**Ratio 3 – 4**	**Ratio 4 – 5**
185g	Cypress 2.9mm	70	188	360			2.69	1.91		
154g	Cypress 2.5mm	59	158	304	501	742	2.68	1.92	1.65	1.48
309g	EIRW 3.0mm	62	188	356			3.03	1.89		
256g	EIRW 2.5mm	51	155	292			3.04	1.88		
200g	EIRW 2.0mm	41	116	226	373	549	2.83	1.95	1.65	1.47
200g	IERW2.0-bound	95	133	215	344	519	1.40	1.62	1.60	1.51

As a picture is worth a thousand numbers in a table, the following graph shows graphically how the thickness of the wood correlates to the frequencies at which the various modes appear. The thicker the wood, the steeper the curve. This appears to be true even when the woods are quite different in character. The light blue line is the bound rosewood pictured on the right above.



Visualizing data makes the difference between having data and understanding it. Looking at numbers in a table like the one above can be a daunting task if one is expecting to make sense of things. The photos help understand what is actually vibrating, the table and the chart help us to make the cognitive leap from raw numbers to relationship. It bears mentioning that at this point there is no correlation to good, bad or indifferent instruments. This is just to try to understand more about the acoustical properties of wood as they are shaped into musical instruments.

What I take away from this, at least on a large view, is that the same basic patterns and ratios between them persist on the plates of a guitar during construction. They change somewhat, but the basic forms remain the same. As shown here, the long modes continue to manifest in spite of a rather drastic change, binding the edges. It is also of interest securing the edge of the plate results in increased frequencies for the first two long modes and decreasing frequencies for the upper 3 modes. Looking at the graph, it can be observed that the curve of the lines are not that different, it's as if the free line was merely rotated slightly on an axis point where the two lines cross.

The extent to which any of this matters depends largely on what happens during bracing and assembly of the sides to top and back. To what extent do the resonant frequencies of the back carry through to the finished instrument ?