The elephant's xylophone

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The Thai Elephant Orchestra primarily uses the "Lanna" Thai five note scale that the elephants are most used to hearing. The notes are the fundamental, a minor third, a perfect fourth, a perfect fifth, a minor seventh, and an octave. It is also common to use the minor third as a fundamental as a major mode. Although there was some variation from one string instrument to the next and between different groups, I approximated for the renats using a "just intonation", or pitches expressed by simple ratios (Table 1).

Traditional Thai renats are made of bamboo or rosewood, and will not stand up to outdoor elephant use. To adapt the scale for the elephants performing in the forest, large steel tubes were cut and suspended. Here's how to design one: for hollow pipes, the pitch in frequency is inversely proportional to the length squared, or

$$L = \sqrt{1/F}\,x$$

where L is the length of the tube, F is the desired frequency, and x is an arbitrary length of the pipe for the fundamental.

For instance, the length of pipe for a perfect fifth higher is

$$L = \sqrt{1/(3/2)} = \sqrt{2/3} = 0.8165$$

or 81.65% the length of the fundamental pipe length x.

The pipe lengths for the "just intonation" elephant scale are thus:

Table 1

scale name	*frequency ratio*	*tube length (% fundamental)*
fundamental	1/1	1
minor third	6/5	0.913
perfect fourth	4/3	0.866
perfect fifth	3/2	0.816
minor seventh	9/5	0.745
octave	2/1	0.707

For western tuned elephant renats in pentatonic tuning, so that they play in tune with marine band harmonicas, the increase in frequency for each halfstep is

$$= 2^{1/12} = 1.05946$$

of the lower pitch. For the "twelve equal" elephant scale, pipe lengths are:

Table 2

scale name	*frequency ratio*	*tube length (% fundamental)*
fundamental	1	1
minor third	1.189	0.917
perfect fourth	1.335	0.866
perfect fifth	1.498	0.817
minor seventh	1.782	0.749
octave	2	0.707

To suspend the pipes, holes are cut at the nodes, the points at which the pipe's vibration amplitude are least, which are 22.5% of the distance from the ends. Finally, the pipes are attached to a strong wooden or metal frame with rope (Figure), optionally using knots or plastic spacers to prevent the pipes from clumping.

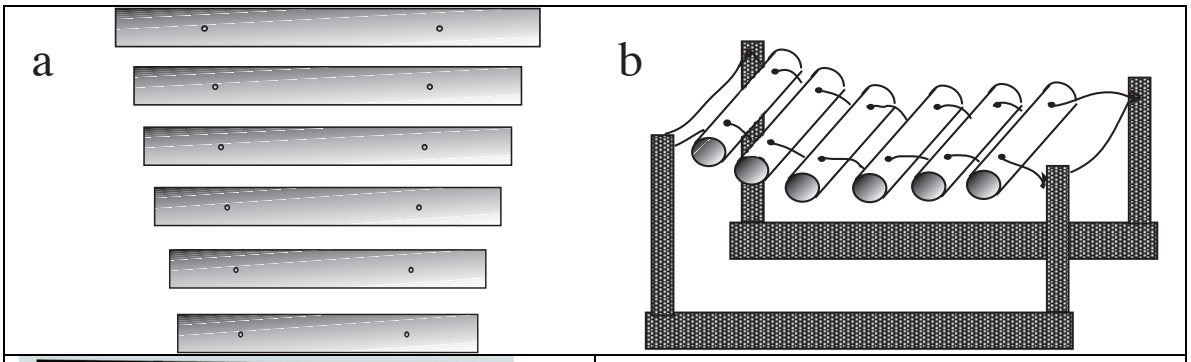

Figure 1. A. Plans for an elephant renat approximating the Lanna Thai scale in just intonation (see Table 1). With this set, the fundamental was a concert C# when the length of the pipe used for the lowest pitch, the fundamental, was cut to 107 cm. a. Design of steel pipes. **B.** Design of pipe suspension. **C.** The renat in action as played by Prathidah, then a seven-year old, and her mahout, Prida Pahkhit. Photograph by Neil Budzinski.

The elephants require little training to perform. Generally a mahout demonstrates the instrument, and the elephant begins to play almost immediately. They experiment a bit on where to hit the instruments, and determine how to make the instrument sound best. Their decisions are invariably the same as human taste, *e.g.*, hitting the pipes where they make a ringing sound rather than a clink.