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PANPIPES AND THE EQUIHEPTATONIC PITCH

by

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Having recently been interested in the tuning of panpipes in the Solomon Islands,[1] I have by accident come across Andrew Tracey's extremely informative article on African panpipes in *African Music*, Vol. III, No. 1, 1971, pp. 73-89. His article deserves further study as it provides more information than he has actually set out. This present essay is an attempt to explore the wider issues which Tracey's article raises.

He is dealing with the panpipe sets made and played by the Nyungwe tribe who live around Tete, some 230 miles up-country from the mouth of the Zambezi River in Mozambique.

Now there are two matters which primarily concern us; first, the *scale* in which the panpipes are laid: and second – and this is the more important issue – the actual *pitch* of the scale to which they are tuned.

On page 77 of his article, Andrew Tracey gives tuning figures for the middle octaves of two panpipe sets, one belonging to Makina and the other to Mbakadiane. These figures are most revealing. A glance at his 'Cumulative Intervals' columns shows that the pipes are tuned to the Equiheptatonic scale[2] with considerable precision, as can be seen by comparing the theoretical cumulative figures for a perfect Equiheptatonic scale with the figures he gives. Remembering that each interval in a theoretical Equiheptatonic scale is, in cents, $\frac{1200}{7}$ = 171.4 cents,[3] the approximate theoretical cumulative column for an octave will be as given below – with which we compare the Nyungwe panpipe figures:

	Theoretical Equiheptatonic	Makina's set	Mbakadiane's set
	1200	1200	1200
	1028	1040	1025
	857	843	855
	685	691	723
	514	523	580
	343	310	357
	171	162	160
Cumulative cents	0	0	0

The deviations in the two sets from the theoretical figures are not consistent (in fact they are random), except for the values for the second notes from the bottom (Theoretical 171) which are both very slightly low, and for the fourth note up (Theoretical 514), where Mbakadiane is definitely too high (580). Indeed, tuning as they must do, by ear, both panpipe sets are remarkably well tuned to the Equiheptatonic scale.

It cannot be too often said that in judging the accuracy of tuning of Equiheptatonic scales it is the Cumulative Cents that one should look at and not the cents values for each interval, because the latter always double the error made in tuning and give a false picture of the tuner's work. For instance, in Makina's set, the cents intervals between the four top notes (1200, 1040, 843 and 691) are 160, 197 and 152 cents. Consider the latter two; 197 and 152 differ by 45 cents. Suppose the tuner had raised the note between them by only 10 cents. The intervals would then be 187 and 162 – a difference of only 25 cents, as compared with the previous 45 cents. So by moving the note only 10 cents, the gap between the intervals has shrunk by 20 cents. This is the important point: the cents intervals always double the errors of the tuner. His real intentions are clearly indicated not by the cents intervals but by the *Cumulative* cents as compared with the theoretical figures.

We have now established the first point about these Nyungwe panpipe sets, namely that they are tuned to the Equiheptatonic scale.

Our next point is to establish the actual *pitch* of the notes at which these panpipes are laid. But before we can do this, it is necessary to consider in some detail, the whole question of how one can determine the pitch of *any* Equiheptatonic scale, whether it comes from Africa or anywhere else, for it is not as simple as it might seem.

Theoretically, an Equiheptatonic scale can be laid at *any* pitch. For instance, if one note is pitched at, say, 200 v.p.s., all the other notes will be progressively 171.4 cents away from it: and the same applies if this note were pitched at 210 v.p.s., 213 v.p.s., 240 v.p.s., or any other vibration number. The great question we have to answer is, 'Does this matter?' – in each case the result is a true Equiheptatonic scale. What we seek to know is this – 'Is there any significant pitch which *inherently belongs* to the Equiheptatonic scale?' In other words, is the PITCH at which it is laid an INTEGRAL FEATURE of this very unusual scale?

Clearly if this can be established for only one single note, it follows *ipso facto* that it will apply to *all* the notes of the scale, however high or low they may be.

I have, over the years, collected some 700 tunings made by myself and various scholars, and the great majority of these tunings are Equiheptatonic. In entering them on my card index I have been impressed how often the pitch of around 182 v.p.s. or its octaves occurs: and I noticed this long before it occurred to me that there might be something significant here.

Let us see if there is any way of testing whether there is indeed a definite pitch at which makers of Equiheptatonic instruments aim to lay their scales. To do so, let us take my figure of 182 v.p.s. to work from.

What we are really trying to establish is how much allowance can be made for human error in tuning, either side of 182 v.p.s., and yet to be able to say, 'This scale is based on 182 v.p.s., and not on some other pitch frequency.'

Let us take three imaginary notes with a gap of 171.4 cents between each. The first step is to divide the intervals of 171.4 cents into two halves and treat the two middle points as separate notes. We shall now have five notes: notes 1, 2 and 3 are 171.4 cents apart, and notes 4 and 5 are also 171.4 cents apart. Therefore they both represent Equiheptatonic scales which are built on two quite different sets of frequencies:

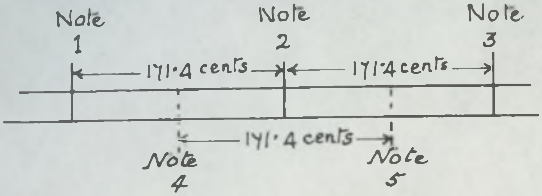


Fig. 1

If note 1 is pitched at 182 v.p.s., note 2 will be 201 v.p.s. and note 3 will be 222 v.p.s. Notes 4 and 5 are halfway between these and will have pitches of 191.3 v.p.s. and 211 v.p.s. respectively. Clearly if an Equiheptatonic scale includes the pitch of 182 v.p.s., ALL its notes will be $\frac{171.4}{2}$ = 85.7 cents distant from an Equiheptatonic scale containing Note 4, i.e. 191.3 v.p.s. Now 85.7 cents is nearly a Western semitone (100 cents) and is plainly recognisable as a shift in the pitch of the whole Equiheptatonic scale however high or low it goes. It is nearly equivalent to the difference in Western music between the pitch of a diatonic major scale in the key of C and one in the key of C♯.

In view of the inevitable human error in tuning – when tuning, as these African peoples do, by ear – no instrument can be expected to be tuned dead accurately – and they never are. How much latitude, therefore, can we reasonably allow each side of, say, Note 1 – 182 v.p.s. – or Note 4 – 191.3 v.p.s. to decide whether the scale is laid at the pitch of Note 1 or at the intermediate pitch of Note 4?

All one has to do is to divide the interval between them – which is 85.7 cents – into half, which gives us 42.85 cents. Let us use 'X' to denote the small intervals which are adjacent to Notes 1, 2 and 3, and 'Y' for those adjacent to Notes 4 and 5. Figure 2 shows what the situation will be:

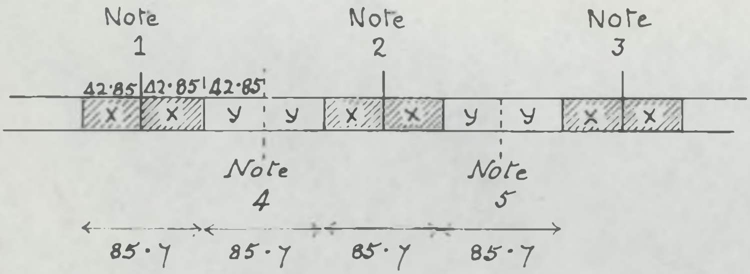


Fig. 2

Now we say that any note falling in the X areas either side of Note 1 shall be counted as Note 1 – i.e. as intrinsically a 182 v.p.s. note – and similarly for Notes 2 and 3: while any note falling in the Y areas on each side of Note 4 shall be counted as being intended to be Note 4, i.e. 191.3 v.p.s. This means that even allowing for considerable human error (± 42.85 cents) we can clearly differentiate two separate scales, each of which is truly Equiheptatonic, but tuned at two completely different pitches.

So we can now draw up a Table of what I call the STANDARD Equiheptatonic pitches, by which I mean an Equiheptatonic scale which contains a note at 182 v.p.s. or its octaves, and on this Table we can include the allowable pitches within which the notes of such a scale must lie. This we have done in the vertical column on the left side of Figures 3 and 4.

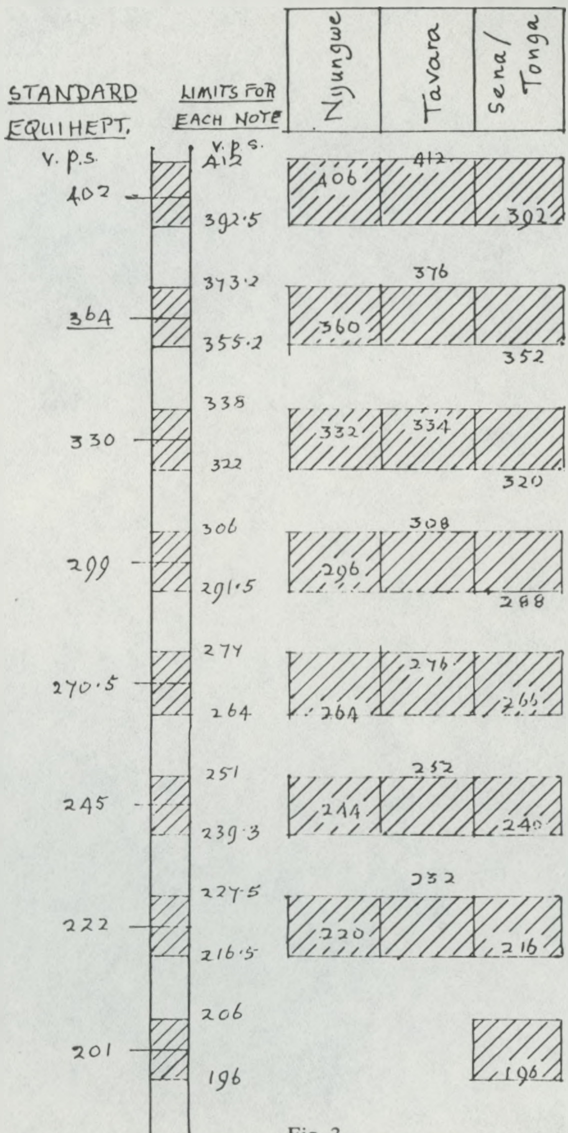


Fig. 3

This is a very sensitive measure and an instrument has to be pretty accurate in its tuning if its notes are to lie within the 'allowable pitches'. Now everyone knows that rustic pipes tend to be uncertain in their pitches. It all depends on how you blow them and how hard you blow, and also on the age and condition of them. Indeed Andrew Tracey himself comments on the difficulty he had in assessing the pitches of these Nyungwe panpipe sets (pp. 76 and 77 of his article). So, before we proceed to assess these panpipes let us turn for a moment to another instrument which is by nature much more stable in its tunings, namely the *mbira* which is used both by the Nyungwe and also by adjacent peoples. Andrew Tracey has sent me three such tunings, the *mbira* belonging to the Nyungwe themselves, to their close relations the Tavara and also to the Sena/Tonga, all three tribes living along the Lower Zambezi River. The tunings of these three *mbira* are set out in Figure 3, and the result is most revealing.

Note first that in the Standard Equiheptatonic column the figure 364 v.p.s. is the exact octave of my 182 v.p.s., so the Standard column is all laid on an Equiheptatonic scale of which 182 v.p.s. is a constituent note.

Now look at the Nyungwe *mbira* figures. Every single one of its notes lies within the 'allowable limits' of my Standard Equiheptatonic pitches, in fact five out of the seven notes are very nearly dead accurate. Here is an Equiheptatonic scale which is undoubtedly tuned to my Standard pitch.

The Tavara *mbira* is consistently tuned slightly on the sharp side. Some of its notes fall in the gaps outside my 'allowable limits' but in all cases except the bottom note (232 v.p.s.) they are much nearer the Standard limits than they are to the middle pitches of the Intermediate scale. No one could claim that this *mbira* is aimed at being tuned on the Intermediate scale: which *ipso facto* means that it is aimed at falling in my Standard Equiheptatonic pitches.

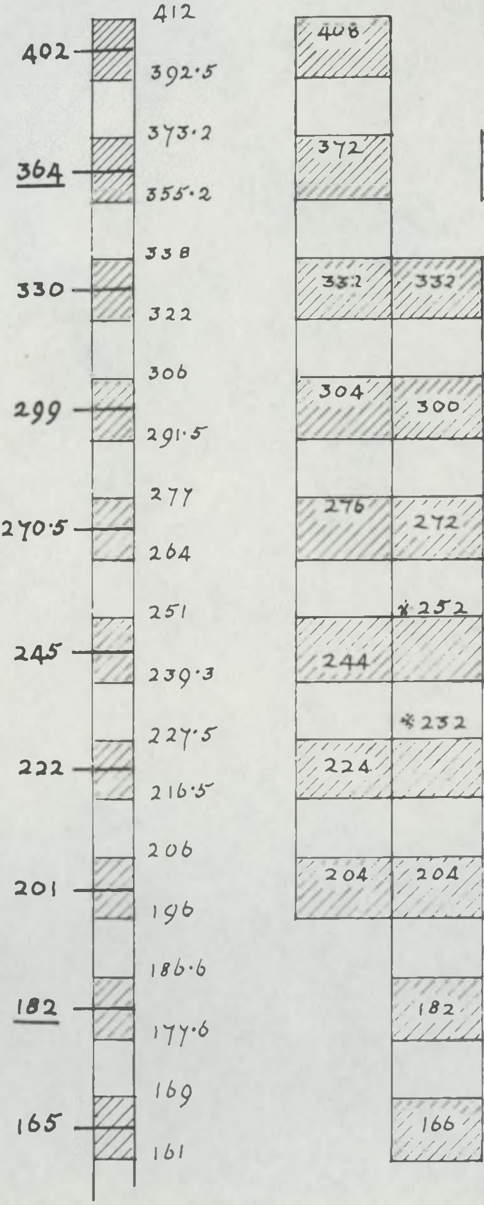
The Sena/Tonga *mbira* shows the opposite tendency. It is consistently tuned on the flat side compared with my Standard pitches, but once again the two notes which fall outside my 'allowable limits' are only just out, and no one could possibly suggest that this *mbira* is aiming at being tuned to the Intermediate scale. It must, therefore, be aimed at being tuned within the limits of my Standard scale.

I only wish that all ethnomusicologists dealing with Equiheptatonic tunings could realise the value of my Standard *schema* which has proved infallible over the last twenty years or so. It is no use just listing the cents intervals between the notes – they tell you very little. It is better to list them as Cumulative cents, but even this leaves out a good deal of information which is instantly revealed by my Standard *schema*.

To return to our *mbira*. So these three *mbira* show that the Equiheptatonic scale used by these three tribes is conceived of as lying at or about my Standard Equiheptatonic pitches, in other words, on an Equiheptatonic scale which includes 182 v.p.s. Especially is this so with the Nyungwe *mbira* which is tuned with astonishing accuracy to my Standard scale. It seems from all this that for the Nyungwe – as well as their neighbours – the equiheptatonic scale exists in their minds at definite pitches. It cannot be pitched just anywhere. In fact if the tunings either of *mbira* or panpipes were at all random, this would at once be shown up on my Table by comparison with my Standard pitches, and the pitches of such a random scale would be scattered indiscriminately both in my 'allowable limits' and also in the gaps between them.

Now Andrew Tracey says that he found that there was considerable variation in the pitches for each note of the panpipes when sounded for recording, and out of the context of the dance. This, as we stated above, is to be expected with simple rustic pipes. He therefore took the *average* pitch for each note and these are the figures we give on the first page of this essay. His figures thus remove any randomness in the tunings and represent what is, presumably, the actual pitch at which the pipe-maker aimed. He could have obtained a more accurate figure for these intended pitches if, instead of taking the *average* for each note, he had calculated the *arithmetic mean*. This mean figure reduces the overemphasis produced by the most extremely divergent tunings, and gives a truer picture of the probable note at which the maker is aiming. However, Tracey's averages do not seem to be far out, and his figures clearly show that however loosely the pipes are tuned, they reveal a quite remarkable essential consistency in the over-all scale they build up.

Furnished with this consideration of Equiheptatonic tunings we are now in a position to return to Andrew Tracey's Nyungwe panpipes.



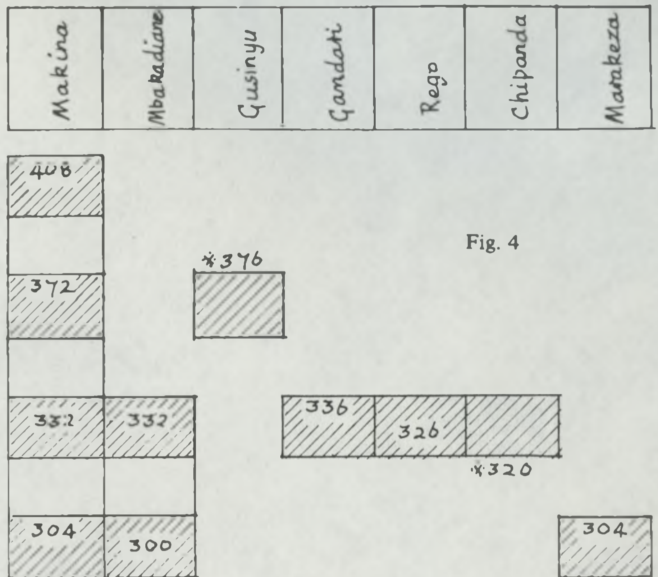


Fig. 4

We have already quoted the tunings of the middle octaves of Makina's and Mbakadiane's panpipe sets. If we now set these tunings against our theoretical Standard Equiheptatonic scale, what do we find? Looking at Figure 4 we see that every one of the notes of Makina's set falls within the allowable limits of my Standard Equiheptatonic pitches. Mbakadiane's set is not quite so well tuned but obviously is tuned to our Standard Equiheptatonic pitches – in fact it actually includes our prime note of 182 v.p.s. exactly on pitch. The two starred notes fall outside our allowable pitches, but 252 v.p.s. is only 1 v.p.s. outside the limit. It is only the 232 v.p.s. note which is really poorly tuned.

Another fact revealed by Mbakadiane's set is that his panpipe set is pitched two Equiheptatonic steps lower than Makina's set. This makes no difference whatever to the actual playing of the Nyanga panpipe dance which Andrew Tracey is explaining, but it does explain why he says (page 73 of his article) that different panpipe sets cannot be played together. Mbakadiane's set is still Equiheptatonic and differs only from Makina's set in that the whole tune of the dance will be played and sung about a Western minor third lower (actually about 343 cents).

Tracey also looked at five other Nyungwe panpipe sets and lists the pitches of the final note of the *Nyanga* tune for each set – which correspond to the top notes already given for Makina and Mbakadiane, though he does not give the rest of their scales. But these top notes are revealing. They are all listed in Figure 3. Of these five sets, in three of them this top note falls in the Standard Equiheptatonic pitch. Gusinyu's set at 376 v.p.s. is only 13 cents sharp (less than one seventh of our Western semitone) and Chipanda's set, at 320 v.p.s., is only 11 cents below the allowable standard pitch. Gusinyu's set is pitched one Equiheptatonic step lower than Makina's; three of the others are, like Mbakadiane's set, pitched two steps lower than Makina's, and the last one, Marakeza's set, is pitched three steps lower.

Altogether we have seven sets of panpipes. Practically all their notes fall in the allowable pitches for our Standard Equiheptatonic scale. It seems to me that there is only one conclusion to be drawn, namely that the Equiheptatonic scale among the Nyungwe does not merely consist of a scale with equal intervals between the notes, but also – and this is the prime point – the Equiheptatonic scale exists in their minds as a scale of a quite definite pitch. It is, in fact, equivalent to the situation in the Western world where nowadays our instruments are pitched to a scale based on A = 440 v.p.s. So we seem bound to say that for the Nyungwe, the actual *pitch* of the scale is an integral part of it.

Now this is precisely the conclusion I came to years ago when dealing with African xylophones:[4] and not only African ones, for it applies also to the Equiheptatonic xylophones of Cambodia.[5] In the paper referred to at the beginning of this essay, I have followed this matter up and I find that all around the world, where Equiheptatonic scales occur and have been measured, they are virtually all tuned to the Standard Equiheptatonic pitch. Andrew Tracey's figures for the Nyungwe panpipes provide one more piece of evidence to substantiate this phenomenon.

This seems to me to be a remarkable fact. It raises in an acute form the question as to whether this Equiheptatonic scale could have arisen independently in various parts of the world, in which case there is no reason whatever, as we have shown, why they should be tuned at the same pitch, or whether the facts force us to admit that there must have been diffusion.

There remains one other piece of evidence from the Nyungwe pipes which points in the same direction. Andrew Tracey, on page 75 of his article, sets out in detail Makina's panpipes. There are no less than 29 sets of panpipes in his 'orchestra', most of them consisting of four pipes bound together. Now the interesting point is that out of the total of 24 sets which contain four (or occasionally only three) pipes, only five of them sound consecutive notes of the Equiheptatonic scale and even then two of these sets are octave duplicates. All the rest of these pipes have a *gapped* scale, that is, they omit one or more steps of the Equiheptatonic scale. Four of the sets omit one of the Equiheptatonic steps, thus making a gap of 343 cents: eleven of them have a gap of three Equiheptatonic steps (i.e. 514 cents) and *Pondoro*, one of the two lower sets, has a gap of four Equiheptatonic steps (i.e. 685 cents). So the principle of the 'gapped' Equiheptatonic scale is firmly embedded in these Nyungwe panpipe sets.

But as I have shown elsewhere[6] the gapped scale is characteristic of Equiheptatonic tunings in xylophones in Africa and elsewhere, and Hugo Zemp and Rudolf Schwarz have recently shown the same feature occurring regularly in the various panpipe sets of the Solomon Islands in the Pacific,[7] which are also tuned to the Equiheptatonic scale.

Andrew Tracey's main concern in his article was to describe in detail the astonishing complexity and interplay of panpipes, voices and dance steps in the *Nyanga* dance: he was not concerned with the Equiheptatonic details we have dealt with. So the figures he gives are a quite independent and unintended confirmation of our Equiheptatonic considerations. And these considerations seem to me to lead to the conclusion that wherever the Equiheptatonic scale is used, and whatever different sorts of instruments using this scale have been tested, the Equiheptatonic scale is found to consist essentially of two factors – first, the notes divide the octave into seven equal intervals: and second, these notes are always tuned to a standard set of pitches which will inevitably include a note at or around 182 v.p.s. or its octaves.

NOTES

1. An essay on this topic is in process of publication.
2. *Ed. note:* I.e. a scale of seven intervals to the octave, all of which are equal. (Cf. the Western scale, for instance, which uses two intervals of different size.)
3. *Ed. note:* "Cents" are an arithmetical system of expressing musical intervals, with the standard: one Western tempered semitone = 100 cents. One octave is therefore 1200 cents.
4. Jones, A.M., *Africa and Indonesia*, pp. 75ff. Leiden 1971.
5. *ibid*, pp. 79-80.
6. *ibid*, 'The formula 1 - 1 - 2 - 1 - 2' pp. 97ff.
7. Zemp, Hugo and Schwarz, J., 'Echelles Equiheptaphoniques des Flutes de Pan chez les 'Are are' (Malaita, Iles Salomon)' in *Yearbook of the International Folk Music Council*, Vol. 5, pp. 85-121, 1973.

Ed: We are particularly pleased to be able to publish this article of the late Fr. A.M. Jones, his last of many which have appeared in this Journal, written about four years before his death on 12th April, 1980. Although very weak from his illness, his enquiring mind continued lively to the end. All Afro-musicologists will miss him, and continue to benefit from the groundwork he laid down in theorising about African musical structure.

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