A STUDY OF THE MICROTONAL VARIATIONS IN FREQUENCIES IN KARNATIC MUSIC

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IN a Conference held in April 1929, South Indian musicologists dicided that the 22 srutis of Bharata in Hindu melodic music have the following relative frequencies : —

European notes	Name of note or the swara	Relative frequency	Cyclic cents
C	Sa	1	0
D flat	ri	256/243	90
		16/15	112
D	Ri	10/9	182
		9/8	204
E flat	ga	32/27	294
		6/5	316
E	Ga	5/4	386
		81/64	408
F	Ma	4/3	498
		27/20	520
F sharp	ma	45/32	590
		64/45	610
G	Pa	3/2	702
A flat	da	128/81	792
		8/5	814
A	Da	5/3	884
		27/16	906
B flat	ni	16/9	996
		9/5	1018
B	Ni	15/8	1088
		243/128	1110

the figures in brackets, differing by a frequency ratio of 81/80, a comma, or 22 cyclic cents.

N.B.—For purposes of clarity, the twelve frets of the vina in the octave may be denominated ri, Ri, ga, Ga, Ma, ma, Pa, da, Da, ni, Ni and Sa higher—the capital letters standing for the *swaras* of the Diatonic Scale—Sa being the open *shadja* string, relative frequency being 1, the higher Sa being of rel. freq. 2 or 1200 cyclic cents.

In fixing the above values for the 22 srutis, South Indian musicologists apparently followed the method originally suggested by Helmholtz[1] and recently also advocated by Fox Strangways[2] and other Western interpreters of Hindu music, of tuning strings by true fourths and true fifths. They also decided in the 1929 Conference that as the shadja has been universally adopted as the fundamental for Karnatic melodic music, the 22 srutis may be defined as given below :—

Sa, $(R_1\ R_2)$ $(R_3\ R_4)$ $(G_1\ G_2)$ $(G_3\ G_4)$ $(M_1\ M_2)$ $(M_3\ M_4)$

Pa, $(D_1\ D_2)$ $(D_3\ D_4)$ $(N_1\ N_2)$ $(N_3\ N_4)$

R standing for Rishabha, G for Gandhara, M for Madhyama, D for Daivata, N for Nishada since Shadja and Panchama once decided on, cannot change in melodic music. Thus the 10 frets in the vina, besides Sa and Pa, have been given twin names. They went so far as to give examples *purely subjectively* of the ragas in which the several R's, G's, M's, D's and N's appeared in present-day melodic music, although the ascent and descent of swaras in ragas may continue to be defined by the 12 frets of the vina. To cite one instance, they laid down that da of Saveri raga is D_1 and has a relative frequency of 128/81.

Prior to the Conference mentioned above, the writer of the present note had studied the variations of the frequencies with the help of a Sonometer and in a paper, he had shown that there are, in Karnatic music, several prolongable notes in an octave, at which the human voice can stand for a definite length of time and which can be easily produced on the violin without a *gamaka* by means of the bow; and in the same paper he had avered that the *small semitone* as defined by Ellis[3] (relative frequency 25/24 above Sa) and the corresponding note above Pa of relative frequency 25/16 are prolongable notes and that, as the voice cannot stand steadily at frequencies 256/243 and 128/81, gamakas are produced from the above prolongable notes, as in ri and da of Saveri raga.

From his personal experience in violin play, the author had also reasons to doubt whether the difference in frequency in the 'andolika gamaka' *within the same swara*, viz., i. in Ri of Madhyamavati raga and ii. in Da of Begada raga could only be a comma (rel. freq. 81/80) as would appear from the theory of 22 srutis mentioned above or whether the variation was not much more.

With a view to finding a solution to these questions, the present author had arranged with the National Physical Laboratory, London, in 1933-34, to take photographs of vibration curves of the gamakas by means of a Duddell Oscillograph, and for purposes of their measurements, the gamakas were played by the writer on his violin according to the standard classical style. Relevant extracts from the Report of the Director of the National Physical Laboratory dated the

12th February 1934, given to the author, in this connection, are reproduced below :—

"The sound from the violin was received by a condenser microphone distant about 2ft. from the violin, and connected through a valve amplifier to one of the vibrators of a Duddell Oscillograph. The wave form of the sound was recorded on photographic paper by means of a revolving drum camera attached to the oscillograph. A time scale was provided on each record by a second vibrator which registered the wave form of the electrical output from a standard valve maintained tuning fork, operating at a frequency of 1000 cycles per second. The player and the receiving microphone were situated in a lagged cabinet so as to avoid as far as possible, any interference from extraneous noise. Communication between the player and the operator of the recording apparatus was maintained by a system of visual signals, controlled by the mechanism of the shutter on the recording camera, the player being warned one second in advance of the opening of the shutter and also at the commencement and conclusion of the exposure. The duration of the exposure was approximately one second in each case.

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"In all, seventeen records were made," (each record measuring 47 cm. C. S.)

etc.,as registered by the oscillograph records have been worked out and analysed by a Physicist and a full report about the same is being published elsewhere.

The important results are however, briefly summarised below :—

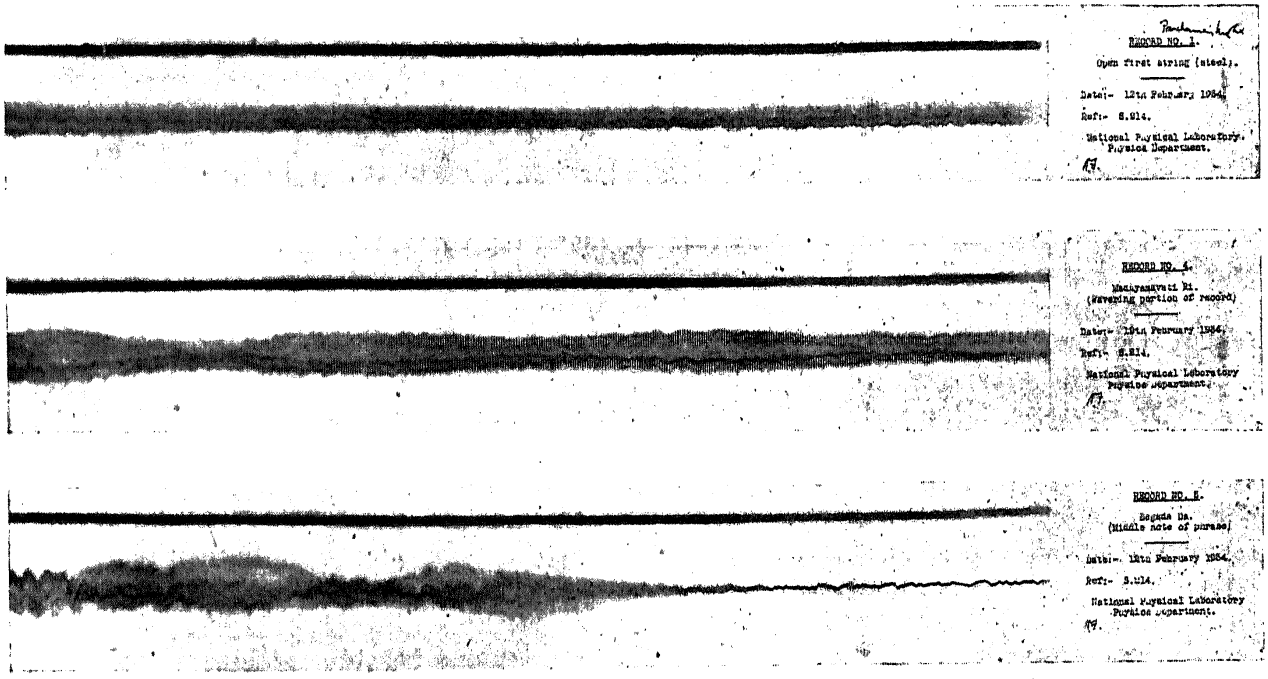
i. In da of Saveri raga, the variation (or gamaka) is from rel. freq. 25/16—a small semi tone above Pa—to rel. freq. 8/5—a semitone above Pa *i.e.*—a measure of 42 cyclic cents. On analogy, the gamaka in ri of Saveri raga will be from rel. freq. 25/24 to 16/15.

ii. The gamaka or variation in Ri of Madhyamavati raga is from rel. freq.10/9—(a minor tone above Sa) to rel. freq. 8/7 *i.e.*, a measure of 49 cyclic cents.

iii. The gamaka in Da of Begada is from rel. freq. 5/3 (a minor tone above Pa)—to rel. freq. 12/7 *i.e.*, a measure of 49 cyclic cents, a ratio of 36/35 subsisting between 9/5 and 7/4.

It is interesting to note that the variations in frequencies within the same swara are *quarter-tones* of definable frequency, which exist between notes arising at certain aliquot parts of the Sa and Pa strings. In (i) above the variation is 42 cyclic cents, while in cases (ii) and (iii) it is 49 cyclic cents.

The above is merely a preliminary study and does not claim to settle finally the important questions relating to the microtonal



The oscillograph records in respect of a few of the interesting gamakas are reproduced below :—

The frequencies of the various gamakas, variations in frequencies in Karnatic music. It is, however, the considered opinion of the author that these questions can be decided satisfactorily only by *objective*, and not by

subjective, methods. For instance, the author would suggest the frequencies should be actually measured by modern scientific methods similar to those outlined on this note. With a view to avoiding unnecessary controversy, the author would also suggest that the gamakas should be produced for purposes of these experiments by recognised masters of the art of violin play.

1. Helmholtz, "Sensations of Tone-p. 280. Translation" by Ellis. 2. Fox Strangways, "The Music of Hindostan (1914), p. 117 & his article on 'Music' in the *Legacy of India*, p. 311. 3. Ellis, "Helmholtz's Sensations of Tone," pp. 453 and 456.

INDIAN DAIRY RESEARCH INSTITUTE

THE Indian Dairy Research Institute, Bangalore, celebrated its Silver Jubilee last month. The Institute had a very chequerd career during its period of existence, and cannot as yet be said to have crossed the final hurdle. It is the youngest of the central institutes devoted to one of the most important branches of applied agriculture, and started its career at Bangalore as Imperial Institute of Animal Husbandry and Dairying in 1923 under the able guidance of the late Mr. William Smith. The main functions of the Institute were to develop foundation herds of important Indian milch breeds, and train personnel in the modern methods of dairy husbandry. Though a Scotsman by birth, Mr. Smith was a lover of Indian cattle, and inspite of many difficulties and obstacles the young Institute had to face, he succeeded in laying a strong foundation, and inspired his staff and students to the noble ideal of service to the cow. The Institute which was functioning as a section of the Imperial Agricultural Research Institute was reconstituted in 1936 into an independent department and the name of the Institute changed to the Imperial Dairy Institute. The question of expansion of the Institute has been engaging the attention of the Government of India for a long time, and a small beginning was made in 1940 by opening a new Imperial Dairy Research Institute at Delhi with the late Dr. Davies as its first Director. Due to various circumstances it was transferred to Bangalore in 1941, and in course of time the two institutes were combined into one under the name of Indian Dairy Research Institute. The proposal to expand the Institute, so that it will be in a better position to render active help to the country's biggest industry, is still under the consideration of the Government of India, and it is hoped that many suggestions that have been made will bear early fruits.

In course of its work the Institute has been able to develop fine pedigree herds of Gir and Sindhi cows and Murrah buffaloes, and distribute its surplus stock all over the country. The Institute has also an artificial insemination centre which will no doubt contribute a great deal towards the improvement of local stock. The service is gratis, and so far over 3,000 inseminations have been done with striking success.

Another important activity of the Institute is training of personnel in modern scientific methods of dairying. The Institute gives a two years diploma course, called Indian Dairy Diploma, recruiting nearly 35 students every year. In addition there is a short-course especially useful to man in the trade. Honorary workers are also taken for post-graduate work in dairy husbandry, dairy bacteriology, dairy chemistry and dairy technology. There is now a proposal to open a degree course in dairying.

The Institute has been able to develop its scientific sections considerably since 1941 under its able directors Dr. Zal R. Kothavalla and Dr. K. C. Sen. During this short period some interesting and important problems have been tackled. To cite only a few: study of the variation in the quantity and quality of milk due to different feeds and seasons, utilization of different feeding stuffs and bye-products of industries, chemical composition of milk and milk products, freezing point of milk, enzymes and vitamins of milk, composition of ghee, storage properties of butter and ghee, standardisation of methods of manufacture of dairy products, standardisation of chemical and microbiological methods of analysis of milk and milk products, nutritive value of milk and milk products, bacteriological quality of market milk, keeping quality of milk, microflora of dahi and butter, etc., etc.

With this brief description of the manifold activities of the Institute we wish it many useful years of active service for the benefit of our country, and its premier industry—dairying.