The ENTOMOMUSICOLOGY
Or
The BUZZ THEORY[1]

se none e vero e bene trovato

The third Ethnomusicology conference took place in Wegimont, Belgium, from September 7th to September 12th, 1958 and was initiated by the International Circle of Ethnomusicology Studies. This conference ended with Jacques Chailley's intervention on "Ethnomusicilogy & Classical Harmony". The musical education renewer began his conference by quoting François Bacon, who, in his Novum Cantorum published in 1620, threw the basis of Modern Science by noticing how important it was to "observe the resemblances and analogies of things, either on the whole or in the details, because they are the link and the unity in nature and begin to comprise the sciences". Jacques Chailley encouraged musicologists to absorb this point of view: firstly to worrys about analogies amongst diverse musical expressions, then to compare the basis of the intervals, in order to highlight the similarities in the structures in use. He asserts that these links will confirm the Universality of music in its origins. This method of investigation reminds us of a linguistic approach, coming to the conclusion of the existence of a "Indo-European" mother-tongue. Does that mean all musics (tunes?) would emanate from an ancestral mother-music gradually differentiating itself, and that the original matrix would imply a naturalistic justification yet to be discovered ?
Has the recorded Universality of the intervals of the octaves and fifth imposed itself? Is it in fact, unavoidable? Jacques Chailley in the end recalls that a good understanding of modern harmony requires the knowledge of classical harmony, of the renewed language which was its prior, the latter being itself the heir to the medieval language etc… For these reasons, Chailley concludes that Antiquity cannot be understood without the lights of ethnomusicology, and finally wonders:
"Who even knows if one day we won't have to ascend from ethnomusicology to zoo- or entomomusicology[2] ?"

When mosquitoes Bzz buzz

On a September 2010 night, a mosquito woke me up. Though I don't have the absolute pitch, I get the intuition that the frequency [3] produced by its flight is very close to the diapason[4]. My

[1] Translation : Calvet, *Zen étude & Anglais in France.*
[2] Entomomusicology : when I thought I had created this designation, I found out on the Internet that Jacques Chailley was the one who initiated it first, more than 50 years ago. Since then, this term seems to have been through a long time of deep hibernation, as well as an eventual so-called discipline.
[3] Frequency: what we call frequency is the number of vibrations per second, produced by a precise object at a precise time. Thus, a music note or a number of an insect wing-beats is expressed in "number of beats per second" called *hertz* (Hz). Humans perceive the frequencies between 20 and 20,000 Hz.
[4] Diapason: the diapason frequency is determined at 440 Hz. About this topic: Leipp. Emile. *Le problème du diapason.* Bulletin du G.A.M. N°3. 1964.

curiosity is so strong that I need to check. The piano confirms a note barely lower than G#. The following night, I wake up again, but this time the frequency of the intruder is much higher, close to a blue note. The piano asserts it is an approximate Eb. I conclude that the insect is faster than the one of the previous night (?). One and a half time faster, because Eb is one interval[5] away from the fifth G#. Or, maybe it is a different mosquito (?). Two clicks and two key-words "frequency mosquito" later, the answer shows up on my computer screen: the discovery of two American researchers published in the very serious and famous magazine *Science*:

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Harmonic convergence in the love songs of the dengue vector mosquito.

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Abstract

"The familiar buzz of flying mosquitoes is an important mating signal, with the fundamental frequency of the female's flight tone behavior her presence. In the yellow fever and dengue vector Aedes aegypti, both sexes interact acoustically by shifting their flight tones to match, resulting in a courtship duet. Matching is made not at the fundamental frequency of 400 hertz (female) or 600 hertz[6] (male) but at a shared harmonic of 1200 hertz[7], which exceeds the previously known upper limit of hearing in mosquitoes. Physiological recordings from

[5] Intervals, frequencies ratios and quotients :

Notes of the chromatic scale on C	Name of the interval produces with a fundamental (here with C)	Frequencies ratios	Quotients
C	Unison	1/1	1
C#	Minor second	25/24	1,0417
D	Major second	9/8	1,125
Eb	Minor third	6/5	1,2
E	Major third	5/4	1,25
F	fourth	4/3	1,333
F#	Decreased quinte	45/32	1,4063
G	Quinte	3/2	1,5
G#	Minor sixth	8/5	1,6
A	Major sixth	5/3	1,666
Bb	Minor seventh	9/5	1 ,8
B	Major seventh	15/8	1,875
C	Octave	2/1	2

[6] 400 hertz and 600 hertz : the frequencies produced by the male and the female have a frequencies ratio of 600 / 400 = 3/2 or 1,5.

[7] 1200 hertz: this frequency corresponds to: 400 x 3 or 600 x 2!

Johnston's organ (the mosquito's "ear") reveal sensitivity up to 2000 hertz[8], consistent with our observed courtship behavior. These findings revise widely accepted limits of acoustic behavior in mosquitoes. "

The symphonic Orchestra

After the surprise produced by this revelation, I asked myself**:** do harmonic relations exist between the frequencies produced by their beatings of wings of all the flying insects, or are mosquitoes an exception?
Aware of the fact that these notes may be **average** or approximate results, I randomly write from web pages the frequencies of some other insects' wing beats. I submit the operations to binary divisions to achieve a result lower than two to be able to name[9] the interval.

Insect		hertz									
Aeshna cyanea	A	35									
Aeshna isoceles	B	40	B/A	1,14 ?							
Sympetrum striolatum	C	45	C/B	1,125	C/A	1,285 ?					
Cordulie arnea	D	65	D/C	1,444 ?	D/A	1,857 ?	D/B	1,625 ?			
Syrphes	E	120	E/D	1,846 ?	E/A	1,714 ?	E/B	1,5	E/C	1,333	
Mouche	F	200	F/E	1,666	F/A	1,428 ?	F/B	1,25	F/C	1,111 ?	
										F/D	1,666

The ratio between the frequencies gives surprising results which reveal an in contestable musicality :

1,5 : fifth ; 1,333 : fourth ; 1,666 : major sixth ; 1,25 : major third ; 1,125 : major second.

More than a third are pure harmonic relations, and more than a half (7/12) if we get rid of Cordulie arnea (D) which obviously distorts the whole. So I decide to have a look at a specialized book by Joël Héras[10]. Then I carefully write all the results down, without exception, with all the minima and maxima given for some insects.

[8] 2000 hertz: (for a long time we thought that the females were deaf, but it is not true!) The maximal frequency that these insects can hear is a harmony away from the frequencies produced when flying or by putting in phase together.
- 2000 = 400 x 1.25 x 2 x 2 = 2 octaves and a major third.
- 2000 = 600 x 1.66 x 2 x 2 = 1 octave and 1 major sixth.

[9] Naming the interval: let's take 2 frequencies of 120 Hz and 320 Hz. 320 / 120 = 2.66 doesn't tell us anything new. 2.66 / 2 = 1.33 means that the frequencies 120 and 320 Hz are 1 octave + 1 major third away from each other.

[10] Héras Joël. *Battements d'ailes* (Wing-beats). Delachaux et Niestlé. 2004.

Common name	Latin name	Number of wing beats / second
Hanneton commun	Melolontha melolonthe	50
Grande libellule	Libellulidae sp.	24 à 40
Syrphe prudent	Chrysotoxum cautum	120
Mouche		200
Panorpe commune	Panorpa communis	30
Bourdon des champs	Bombus pascuorum	130
Abeilles		250
Papillon moyen	Soufré colias hyale	8 à 12
Petite nymphe	Pyrrhosoma nymphula	16
Sphinx	Sphinx pinastri	50 à 90

I am surprised to see that the minima and maxima are systematically under a harmonic relation.

- Medium Butterfly: 8 to 12, or 3/2 = 1,5 (fifth)
- Large Dragonfly: 24 to 40, or 5/3 = 1,66 (major sixth)
- Sphinx: 50 to 90, or 9/5 = 1,8 (major seventh)

I only have three examples, which is little, but I notice that the higher the frequencies produced by the flight are, the wider the interval between the extremes is. It is interesting to classify the general results to calculate their ratio.

	Hertz	/A	/B	/C
A	8			
B	12	1,5		
C	16	2	1,33	
D	24	1,5	2	1,5
E	30	1,875	1,25	1,875
F	40	1,25	1,66	1,25
G	50	2	1,041	1,56 ?
H	90	1,406	1,875	1,406
I	120	1,875	1,25	1,875
J	130	2,03 ?	1,35 ?	2,03 ?
K	200	1,56 ?	1,041	1,56 ?
L	250	1,95 ?	1,3 ?	1,95 ?

No need to calculate further back, the overwhelming majority of pure harmonic relations is well-established. We can note that the perfect harmony is disturbed by the last three frequencies. And as I thought, I came to the conclusion that we have here a major element of natural justification to our natural attraction towards intervals of octaves and fifths, so that their use has become universal. This is true for the other intervals. The fourth which is simply the result of the subtraction of the fifth to the octave, the tone which is the difference between fifth and fourth, and what to say about the halves, thirds and fourths of a tone? Our ear, which was much more efficient so long ago, would have “naturally” formed itself? It is true that the opposite would be very surprising! I push my reflection further, considering the relation that must still exist between frequencies and wings length, but no specialised book can answer my interrogations, when my attention is caught by the figures relating to speed in flight. They are extracted from Williams Romoser's book[11]. Let's classify them to calculate their ratios.

	Species	Kind (ordre)	Speed (km/h)	/A	/B	/J	/K
A	Ephémères		1,8				
B	Bumblebee	Hyménoptères	3	1,66			
C	Mosquito	Diptères	3,2	1,77	1,066 ?		
D	Demoiselles	Odonates	5,4	1,5	1,8		
E	Ammophiles	Hyménoptères	5,4	1,5	1,8		
F	Domestic fly	Diptères	6,4	1,77	1,066 ?		
G	Piérides	Lépidoptères	9	1,25	1,5		
H	Calliphora	Diptères	11	1,52 ?	1,83 ?		
I	Moro-sphinx	Lépidoptères	18	1,25	1,5		
J	Domestic bee	Hyménoptères	22,4	1,55 ?	1,86		
K	Aeschne	Odonates	25,2	1,75 ?	2,1	1,125	
L	Anax	Odonates	30	2,08 ?	1,25	1,33	1,19 ?
M	*Cephemyia spp. oestrides*	Diptères	40	1,38 ?		1,785 ?	1,587 ?

Same observation for the flight speeds for which the harmonic proportions are largely dominant.

Landing

If doubt has appeared over a definite reality of the spheres harmony, and if the golden number is scarcely present in all the geometries we can admire in nature, it seems yet that the presence of harmonic relations in the frequencies produced by flying insects is definitively relevant. We must acknowledge here the tremendous intuitive suggestion due to Jacques Chailly's genius. Indeed if the measurements provided by entomologists are correct (and there's no reason to doubt it), it is clear that the octave, fifth, fourth relations won't have waited for Ling Lun's rees[12], or Pythagore's observations in the black-smith workshop[13] to occur.

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[11] Romoser Williams: *The Science of Entomology*. Hardcover. 1981.

[12] Ling Lun: "The legend of Ling Lun was recorded 2,600 years before our era, still in China. Ling Lun heard the song of two phoenixes, a male, a female. Each song was composed of six notes. Ling Lun, music master, cut bamboos of equal diametre, and reduced their length achieving the right notes. The twelve tubes gave the *lius* (laws) and were brought to the Emperor Huangdi. . Moreover – according to the legend – the twelve bamboos were tuned on until the whisper of the yellow river (Huanghe), which note is provided from a bamboo cut between two knots, that is to say at the note's octave of the entire segment. This observation is one of the rare "natural" justifications we have about the diapason to come…". Quotation extracted from my *Avant Temperament ;* Soon to be published.

For so long, this simplistic physics has been recorded in the wing-beats of odonates, diptères and other hyménoptères, that there is much to theorize that a refined study of Entomomusicology will reveal the presence of a series of harmonics by the spectral analysis of the sound produced by the flying insects :

the BUZZ !

[13] The black-smith workshop : “The legend of the hammers attributes to Pythagoras the discovery of the simple relations of octave 1/2, fifth 2/3, fourth 3/4, which proportions are established from the first natural numbers. The tone ratio 8/9 is obtained by deduction (fifth minus fourth = tone. 2/3 : 3/4 = 8/9)”. Extract from my *Avant Temperament ;* Soon to be published.