

Why the loading of gut for lute bass strings is the only hypothesis that fulfils the requirements of seven criteria arising from a consideration of historical evidence, by Mimmo Peruffo

For we see, that in one of the lower strings, there soundeth not only the sound of the treble, nor any mixt sound, but only the sound of the base (Francis Bacon, *Sylva Sylvarum* 1629)

Introduction

Concerning gut bass strings, that were employed in past times on lutes with more than six courses, there are still today many unanswered questions.

The questions start to arise from the second half of the 16 century, when a seventh course was routinely added to the lute, tuned a fourth, sometimes a fifth below the sixth course, as Le Roy testifies in 1574:

The Lutes of the newe invention with thirtene strynges, be not subiecte to this inconvenienc, where of the laste is put be lowe: whiche accordyng to the maner now abaies, is thereby augmented a whole fowerth (Adrian Le Roy, *A briefe and plaine instruction* . . ., 1574).

One question in particular overshadows all others: were these new basses as powerful and efficient as historical sources would have us believe? Considering that they are made of pure gut, this question is indeed a crucial one.

At present there are *only two hypotheses* as to how these strings were made: the first hypothesis is the use of rope construction (either leaving the roped appearance visible or giving the string a smooth finish); the second assumes that the density of the gut was increased by treatment with heavy metal compounds or a very fine metal powder; so-called 'loaded strings'; these can be made either with a high twist, or roped (with a smooth finish).

In this paper I will examine these two hypotheses in the light of seven criteria derived from a considered reading of historical sources. These seven criteria are:

- 1) the size of string holes on old lute bridges,
- 2) the improvement in the acoustic performance of bass strings in the seventeenth century over those of the early sixteenth as recorded in contemporary sources,
- 3) equal tension / equal feel: general implication for string thicknesses,
- 4) the colour of gut bass strings,
- 5) when roped strings were introduced,
- 6) lute basses: smooth finish or bumped construction?
- 7) paintings attesting the pliability and smoothness of lute bass strings.

1) The size of string holes on old lute bridges

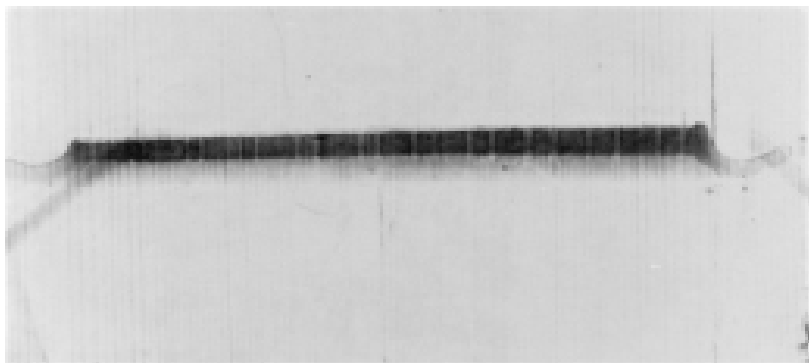
At the beginning of the 1980s, first Ricardo Brané of Florence and then I myself, discovered that the bridge holes on the bass side of many surviving lute bridges were actually too narrow to permit a suitable working tension (more than around 2.5 Kg). There are some exceptions to this evidence but the exceptions are the minority.

In the matter of the holes, one should take into consideration the way they were made. In most of cases, the holes were conical, not cylindrical. It is evident that they were not made in the way that they are made today: I have the idea that the old luthiers employed a very hot, sharp, conical iron tool. In fact, on several bridges I have seen, around the hole (and sometime inside), traces of burnt wood. However, in the face of this initial evidence, I have made a thorough investigation over many years

studying the surviving lutes of nearly a dozen museums with the intention of collecting all the gauges of the holes on the bass side of the bridges. In total I have collected the bridge-hole diameters for about 100 lutes or more.



Measuring lute bridge holes



Johann Seelos 11-course lute. X-ray of bridge, showing narrow and conical holes in the bass side.



However, for the final calculations, I have considered only around half of them: those with significant indications of the bridges being the original ones. I have written two articles showing all the measurements/data and the related calculations.^{1,2}

After this first task, I obtained some further measurements taken on lutes from some private collections. Then in 2005 I had a chance to visit an Austrian convent close to Linz and took the hole gauges on some very interesting 11- and 13-course Lutes (I have not published any article yet on this matter, however, the bridge holes of most of these lutes confirms the evidence that they are too narrow for pure gut basses):



'Magno Dieffoprifar 1604'



'Hans Frey Bologna/Fux 1683'



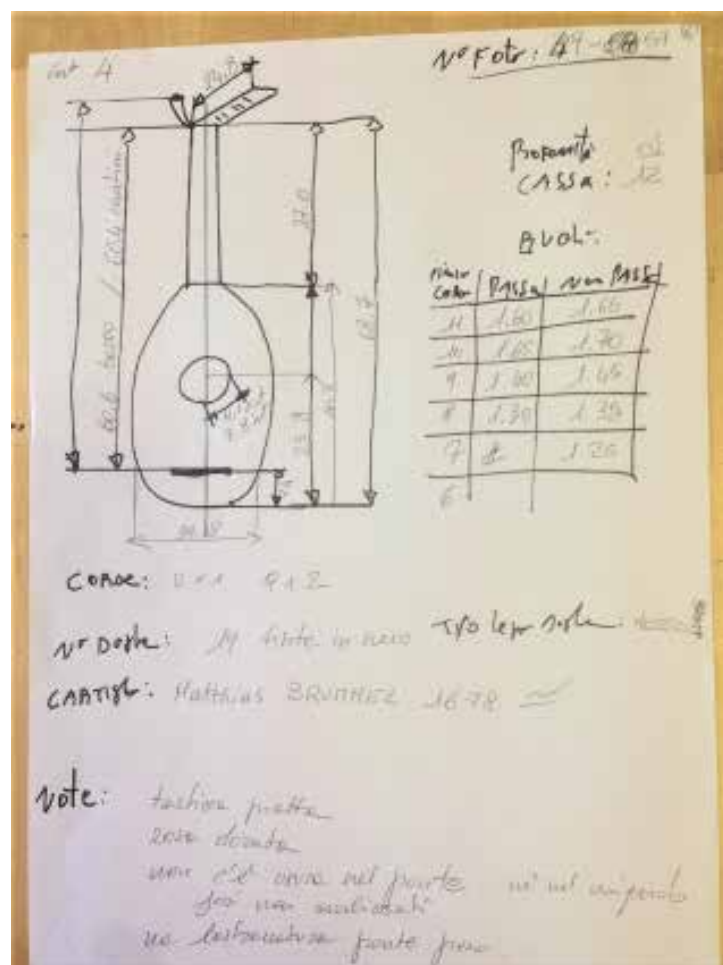
‘Weiss’



‘Matthias Brummel 1678’



Anonymous



Example of a schedule with the hole gauges (Kremsmünster, 2005)

It will be worth mentioning that a bridge-hole diameter is obviously not the actual diameter of the old string passing through the hole. The hole was made, of course, with a certain empirical oversize.

Based on all my data, Ephraim Segerman then calculated a range of tension from 1.1 to 1.8 kg. In his work, the actual maximum string diameter was considered as equal to 85% of the maximum string-hole diameter. I think that this was a good figure.³

It is also good that these calculations were done by him and not by me: in fact, he is the scholar who introduced the roped string theory in the 1970s; he thinks that the loaded gut theory has no historical evidence.

There is one more open question concerning these holes: can the original diameters become enlarged or shrink over the time? I have put this question to some famous wood restorers here in Italy (in Florence and Milan) and the answer was that wood, generally speaking, becomes weaker over the time and even under bacterial attacks, weather changes etc etc; so one can expect the holes to become enlarged under this effect over the centuries.

What about the dust in the inner portion of the holes? Might it contain traces of metals or oxides that were added into the string? In fact I have taken the decision not to take samples: after all these centuries it is easy to come to wrong conclusions.

I discovered a 'mistake' in Segerman's work, however: he only considered low twist gut in his calculations, with a density of more or less 1.3 (but low twist gut does not work at all in the basses: their stiffness, in other words, their inharmonicity is too high), so we should consider the only other plausible explanation for the historical gut lute basses; i.e. 'bumped' roped strings, whose density is around 1.1, instead 1.3 of the low twist plain gut.⁴



Smooth roped structure



'Bumped' roped structure

After my corrections, the new value of tensions ranges from 0.9 to 1.5 kg or thereabouts. Maybe some of you have no idea what this means. Try for yourself; drop the tuning of your lute that is probably around 3.0 Kg tension (the most common value in use today) by 9 to 11 semitones and thus you will have an idea what it means to play at 1.0-1.5 kg or so on: is it still possible to play the lute in such conditions? How would they perform? It will be clear to everybody that the strings become slack like rubber bands: no power, no round, clear and prompt sonority, no control of the fingers over the strings, you have pitch distortion, all the strings buzzing on the frets etc. You should do this test once in your life, especially if you have little confidence in the loaded gut theory!

However, the right experiment must be done using roped gut strings, not modern wound strings or the fluorocarbon ones, which both have higher density than gut because they have, of course, better performance than the historical option which is always centered on pure, unloaded gut. Despite that, even with modern basses, you can have a good feel about the whole situation.

My clear and polite question is why did the luthiers of those times not make these bridge holes a bit bigger? This job is indeed very easy to do: many players today enlarge them when they want to switch to thick gut roped strings instead of the 'traditional' nylon wound ones.

We must consider that all those bridge holes were certainly made by the lutemakers of the 17th century to a size able to accommodate any sort of bass gut strings then available on the market. What other explanation is left to us than to assume that the technological matrix common to Lyons, Pistoys

and maybe, in Dowland's case, also the lowest Venice Catlins, must have been the loading of gut:²⁵

Conclusion: if the bass gut strings were not loaded, or made denser in some way, it is not possible to reach an adequate degree of tension, and the same feel of tension in the upper strings implied by historical sources (we will consider below why this is important).

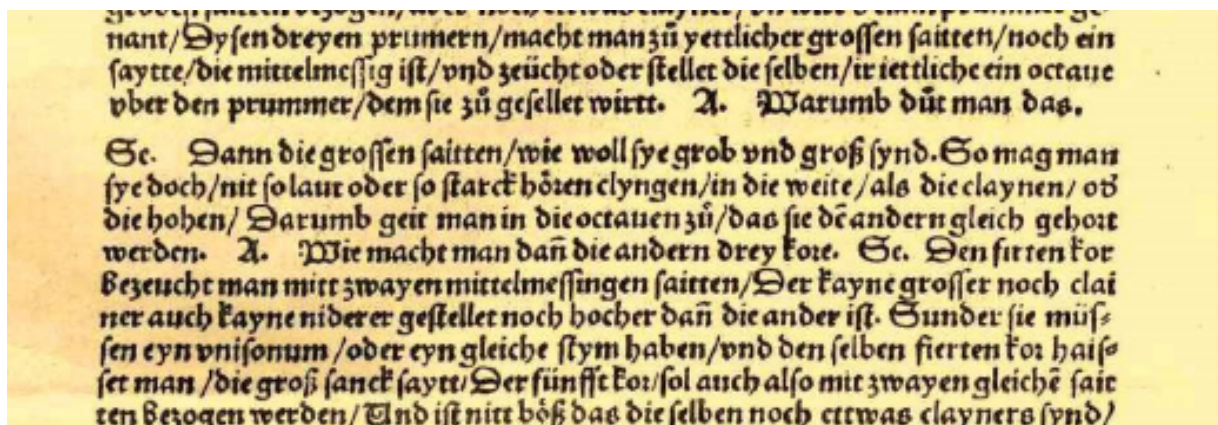
2) The improvement in the acoustic performance of bass gut strings in the 17th century over those of the early 16th as recorded in contemporary sources

There is strong evidence that the lute gut bass strings of the 17th century (from the sixth down to the twelfth course) had better acoustic performance than the basses (fourth, fifth and sixth courses) of the very late 15th century until the 1560s. Johannes de Tinctoris wrote:

An arrangement of five, sometimes six, principal strings was first adopted, I believe, by the Germans: viz. two inner ones tuned in a third, and the other ones in fourths [. . .]. Furthermore, in order to obtain a louder sound, another string tuned an octave higher can be added to each of the principals, except for the first one.⁶

Sebastian Virdung, in his *Musica Getutsch* (Basel, 1511) says:

to all three basses (Prummer) are added strings of medium thickness . . . one octave higher. Why that? Because the thick strings cannot be heard so loud in the distance as the thinner ones. Therefore, octaves are added, so that they be heard like the others,⁷



Vincenzo Galilei, in his *Fronimo* (1568) moreover implies that strings below the sixth course at that time were poor:

and God knows how well one can hear them . . . and . . . although they are perceived by the ear as not very sweet, because of their poor sound . . .⁸

Fr. Mi disse essersi ritrouate, per hauere nel Luto come nell'organo, il pedale. Eu. Ha, ha, ha.
Fr. Miseri loro, che se sapessero quello che nel organo sia reputato il pedale da gl'huomini di qualche valore, si muterebbono di parere sicuramēte, & farebbono appunto da quelli come il pedale da que sti, abborrito & disprezzato, senza fare tutto il giorno tanto schiamazzo quanto ci fanno. Vedere di gratia qual sia l'acquisto loro, ei non ne cauano altro fuor dell'ordinario, che il potere quando a loro piace, tocchare l'ottaua del tenore auuto, & colà quella del bordone, & l'incluse tra queste: le quali ottaua ancora, Dio sa quanto & come se si odono. Se questa loro noua aggiunta di corde, di cesserò haueila trouata & intri odotta per galanteria, & non per necessitā, o ne cauassero la comodità che con meno potrebbe cauarli, come di non hauere al postare le canz. ni che sono per G sol re vt, ma sonarle ne proprii luoghi & naturali, & se non quelle, almeno quelle che il baf so loro ha segnata la chiave di F fa vt nella prima linea, farebbono di qualche scusa degni, ma cō esse non hanno per ancora saputo fare, piu di quello hauete inteso, ben che con poca dolcezza venghino quelle ancora dall'vdito comprese, mediante la debilitā del suono loro.

By contrast, Mace (1676) and the Burwell lute tutor (1670s), wrote that the all-gut basses of their time, installed on a lute with a (short) extended neck, were powerful enough to cover and ‘confound’ the sound of the upper strings. Burwell speaks of ‘. . . the confusion that the length of sounds produce’ and ‘. . . every bass cannot make a concord with every small string . . .’ and, talking about the eleventh course, ‘. . . the lutemasters have taken away that great string because the sound of it is too long and smothers the sound of the others.’ Maces says that ‘This inconvenience [i.e. the power and persistence of sound of the basses which causes confusion and dissonances with the higher registers] is found upon French Lutes, when their heads are made too long; as some desire to have them. . .’¹⁰



This is the short-extended neck probably mentioned by the Mary Burwell lute tutor in ‘English’ [Jacques] Gaultier’s portrait.

Be aware that this is not a subjective opinion but a comparison between the upper strings and the basses: in practice, the same comparison can be made even today; this is not a subjective matter of feeling and is not affected by the personal sensibility or the tastes of the players of those times. Today anybody can check that even the best roped strings do not ‘cover and confound’ the sound of the upper strings at all; instead, they are dull and weak, in comparison with the upper strings.

There are other less well-known sources that describe, in a subjective way, the performances of the new lute basses. Giulio Cesare Brancaccio’s letter (26 February 1581) addressed to the cardinal Luigi d’ Este concerns the purchase of a lute as gift for his brother Alfonso d’ Este:

L’altro è che potendosi trovare un leuto à otto ordini, come li suol fare perfettissimi un Maestro Tedesco ch’è in Padova nomato Mastro Venere Alberti faria piacere à S. Altezza [Alfonso d’Este] di presentarglielo: il qual leuto havendo poi à servir per me, desidero che sia delli ordinarij, in quanto alla grandezza, et que’ dui ordini bassi più delli sei costumati siano li bordoni fermi, et sonori d’una corda per ciascuno, et non di due, et infine che ‘l leuto sia armonioso et argentino, cioè con suono chiaro et sonoro, et che i bassi rimbombino il più che si può

[The other thing is that being able to find an eight-course lute, as a German master who is in Padua is accustomed to do, named Master Venere Alberti, it would please his Highness to present it to him, which lute having then to serve for me, I desire that it should be ordinary as to size, and that the two bass courses, more than the accustomed six, should be solid and powerful bourdons, of [only] one string, and not of two, and finally that the lute should be harmonious and silvery, that is with a clear and sonorous sound, and that the basses should resound [/thunder] as much as possible]

(quoted in M. Bizzarini, *Marenzio. ‘La carriera di un musicista tra Rinascimento e Controriforma’*, 1998, p. 40)

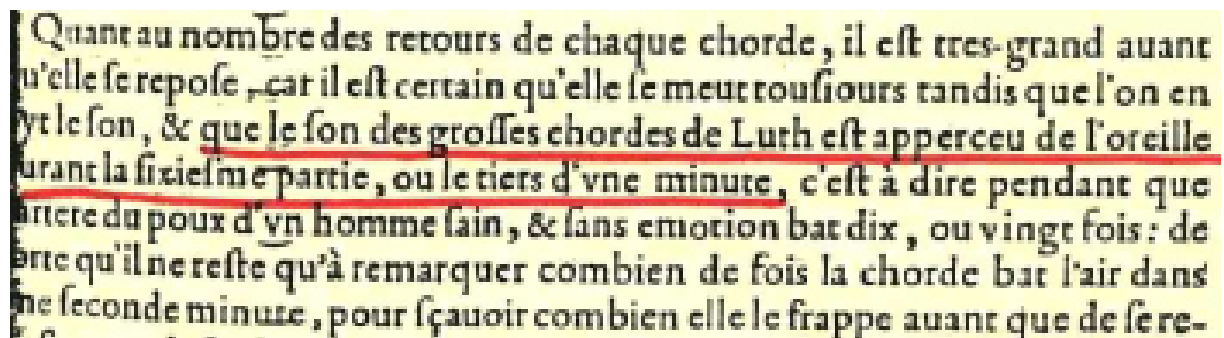
Francis Bacon (1629) wrote:

For we see, that in one of the lower strings of a lute, there soundeth not the sound of the treble, nor any mixt sound, but onely the sound of the base.

Edward Benlowes, (1603–76):

still torturing the deep mouth'd Catlines till hoarse thundering diapason should the whole room fill.

Mersenne in *Harmonie Universelle* (Paris, 1636) wrote that the sound/vibration of the thicker lute bass string (the 11th) was of 20 seconds almost: I have never heard, honestly, this acoustic quality on a modern bumped/smooth roped string (but even with modern nylon wound strings! I think that this affirmation was exaggerated or not real)



Quant au nombre des retours de chaque corde, il est tres-grand avant qu'elle se repose, car il est certain qu'elle le meurt tousiours tandis que l'on en oy le son, & que le son des grosses cordes de Luth est apperceu de l'oreille durant la sixiesme partie, ou le tiers d'une minute, c'est à dire pendant que l'artere du poux d'un homme sain, & sans emotion bat dix, ou vingt fois: de sorte qu'il ne reste qu'à remarquer combien de fois la corde bat l'air dans une seconde minute, pour sçavoir combien elle le frappe avant que de se re-

Conclusion: a modern unloaded gut string on the bass side does not have such a powerful performance as that described by the sources of the 17th century, in comparison with the upper strings.

3) Equal tension/equal feel: general implication for string thicknesses

Several early sources say that the tension of the strings should feel the same across the different courses, and there has been much debate as to whether this means literally the same measured tension (there is some evidence that this is the case for violins) or, as I believe, equal feel of tension, which is not quite the same thing.

But at all events, considering the equal tension/equal feel profile (as suggested by J. Dowland, the Burwell Lute Tutor, Thomas Mace), if the basses actually worked at those very low tensions (0.9–1.5 kg, as calculated by Ephraim Segerman and modified by me), and being non-loaded natural gut—i.e. a whole set-up of thin strings at low tensions—the first string would have to be from 0.26 to 0.32 mm gauge; the second course around 0.36–0.38 mm and the third around 0.48–0.50 mm. I have never seen such a thin first gut string in all my life: in my experience, such a thin lamb intestine does not exist in nature.

In practice, it is not possible to produce them at all: the very minimum gauge I have been able to make was around 0.42 mm (after a light polishing) which I obtained from a single whole unsplit gut of a lamb of an age of about 1 month (see A. Kircher, Rome, 1650 below, concerning the Roman stringmakers: the first lute string is made using one gut only).^{11, 12}

Actually, the range I have obtained from different samples of single, whole lamb guts of different provenance had a minimum gauge of 0.40 minimum and a maximum of 0.48.

De Chordarum Testitudini inducendarum ordine, situ, Concordantia .

TEstudo , & Thiorba chordis non metallicis, sed nervis constant , ex animalium intestinis confectis ; proportio chordarum in testudine , quo ad longitudinem est eadem, sunt enim omnes longitudine æquales, crassitie differunt ; Omnes quoque duplicatæ sunt , excepta vltima , quam vt dixi cantarellam vocant , simplicis proportionē vnus ad alteram in crassitie, Practici desumunt ex multitudine intestinorum, ex quibus conficiuntur, ita hic Romæ grauissimam testudinis chordam ex 9 intestinis conficiunt , secundam ex 8 , & sic vsque ad vltimam , & minimam , quæ ex von intestino constat . Siquis verò ex Mechanicis subtiliùs in hoc negotio procedere

Athanasius Kircher: *Musurgia Universalis* (Rome, 1650)

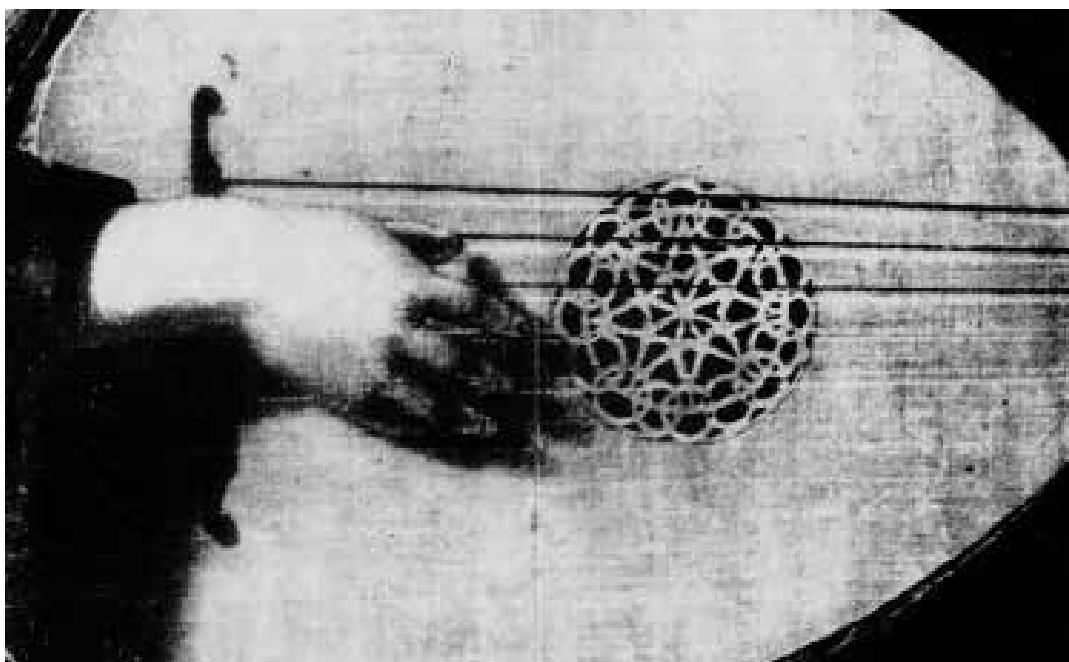
Conclusion: there does not exist in nature any lamb intestine thin enough to produce strings thinner than 0.38-0.40 mm about so it is not possible to reach an equal feel profile of tension on all the strings as indicated by the early sources.

4) The colour of gut bass strings

People commonly think that the question of colour is the 'primordial' evidence in support of the loaded gut theory. This is a misunderstanding: colour actually is just the last point in the scale of things that tell us that these old basses had something interesting in their technology.

The aesthetically pleasing colours for trebles and means mentioned by the old sources were light blue, light green, yellow, light red. On old paintings one can sometime see such strings put on the first to fifth courses; on both the strings of the course or just on one only; coloured strings are also sometimes visible on the octaves of the basses. (Dowland op. cit. fn.5) (Mace op. cit. fn. 10)

Instead, on these gut basses in the paintings, when they are colored, we can see only deep red, deep orange, all gradations of brown, grey, blackish. There is one more thing to see: starting from the sixth bass course down till to the last one, one can see that the colour of the bass series is exactly the same on all of them and it is, generally speaking, in the same position where today we put our modern nylon wound strings, roped gut strings, or even fluorocarbon strings. They even look 'thin', not thick:



Anonymous, second half of the 16th century



Rutilio Manetti, Siena, 1624



Anonymous, second half of the 17th century



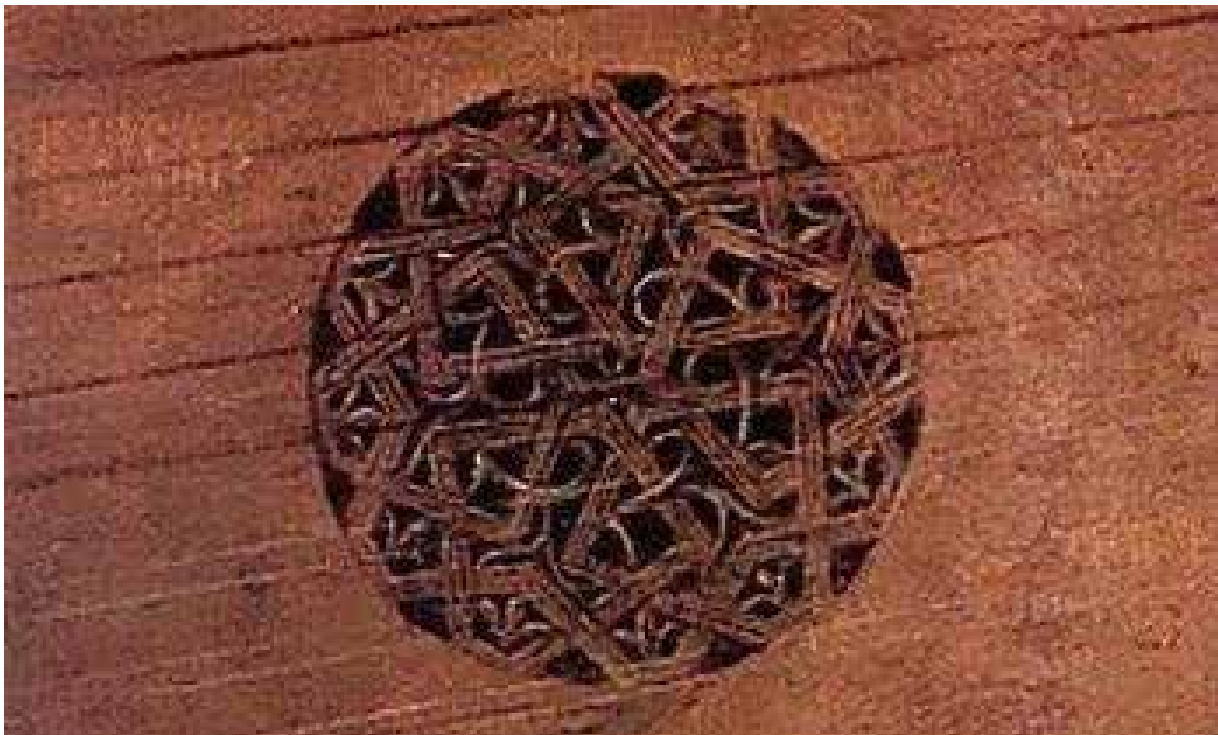
Nicolas Henri Jeaurat de Bertry, second half of the 17th century



Eglon van der Neer, *c.*1677



F. De Troy: portrait of Charles Mouton, c. 1690



F. De Troy: portrait of Charles Mouton, c. 1690 detail



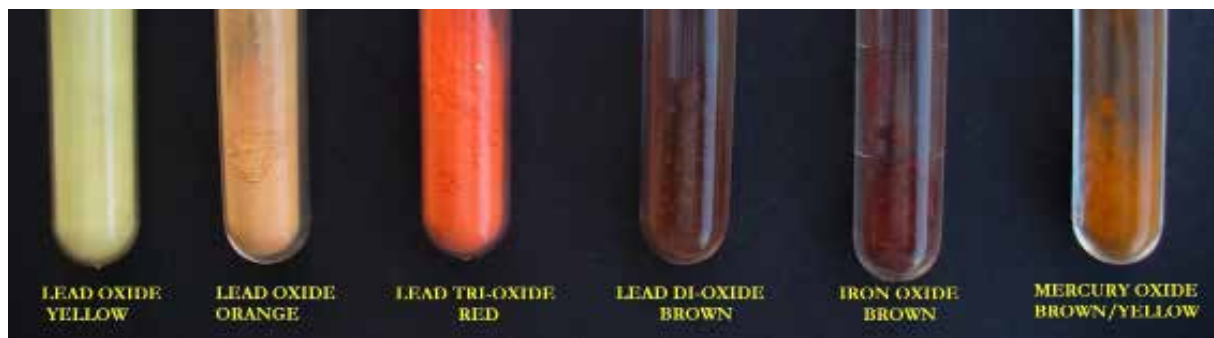
Louis de Silvestre, c.1710

In order to reach a density that is twice that of natural gut (later I will explain why it should be twice) it is indispensable to employ something that has a very high density and is insoluble.

I observe that the denser, insoluble substances widely in use in the 16th and 17th centuries, whose densities are above 8-9 gr/cm³ (mineral pigments such as oxides, sulphides, copper powder etc), are of colours ranging exactly from deep red, all the gradations of brown, dark grey and finally blackish: the same colours we have found on the bass lute strings in old paintings or in written descriptions and lute treatises—a pure coincidence?

There is no trace at all in late 16th to 17th-century paintings of similar gradations in light blue or light green colours anywhere on lute bass strings below the sixth courses; and no mention of light blue or light green in the 17th-century lute basses described in the old lute treatises.

These very heavy and insoluble substances commonly in use in the 16 and 17th centuries were lead and mercury oxides and sulphides, and also fine brown metallic copper powder. There are some mid 16th century recipes that explain how to obtain this.



There is an important point to clarify: it is possible to charge a fresh gut with yellow litharge, brown lead oxide, brown lead dioxide or light brown mercury oxide, so a 17th century painter might have painted the basses with the same colour as the upper strings if these were used, because the colour would not differ much from plain gut.

In other words, it is not true that a gut string that was made denser would automatically have a different colour than the upper strings. Actually, a gut string can be made denser and, at the same time, have a similar colour as the upper gut strings (whose colours, in the old paintings, range from a light yellow down to every gradation of brown: we should be aware that most of these heavy substances I have mentioned have exactly these kinds of colours).

There is an additional option: the 'deep dark red colour' mentioned by Mace for the Pistoys can be intentionally obtained adding some traditional red colours employed by painters to the fresh strings just after the loading process with a heavy agent that might have a different colour (for example orange; light brown etc.) with the intention of characterising the provenance of the string and the manufacturer.



Yellow lead litharge oxide



Cinnabar (red mercury sulphide)

Conclusion: the colour actually is just the last point in the scale of things that tell us that these old basses had something of interest in their technology. Incidentally, the colour of the basses in several 17th century paintings is the same as that of the heaviest insoluble thin pigments/oxides/sulphides/copper powder in use in the 17th century (dark red, dark orange, brown, blackish); no mention in the old written sources of blue, green etc. gut basses. It is possible to have a loaded gut string with a colour similar to natural gut strings (the upper ones).

5) The period when roped gut strings were introduced

Some scholars, even today, still think that 'roped' gut bass strings (i.e. catlines, in Segerman's writings) were introduced around the years 1565–70, when the lute was expanded in the bass register. This thinking should be updated: a few years ago Patrizio Barbieri discovered some sources from the second half of the 15th century where it is very clear that the roped strings, on musical instruments, were already in use.¹³

Actually, roped (gut?) strings were already in use in the late roman imperial period:



Barbieri also demonstrated the presence of special machines called in Italian 'orditori' (ropewalks) a technical term for a special manual machines employed for making ropes, hems etc) in mid 16th-century Roman stringmakers' workshops (Barbieri op. cit, fn. 13)



Considering these new sources, my opinion is that the (smooth?) roped bass strings mentioned in the a source of the 15th century, thanks to their better elasticity compared to a traditional high-twist gut strings, could well have opened the door to the addition of the sixth bass course to 5-course lutes, giving the lute a new acoustic limit or open range of a full two octaves.

By the way: the greater elasticity of a roped string makes the so-called fret sharpness (a problem that happens when a thick high or low-twist string is pushed down on the fret, slightly increasing its tension and therefore raising its pitch) much less evident: actually, no one in lute treatises from the first half of the 16th century complains about it (instead, they mention the tapering/conicity of the lute gut strings as a real concern (Capirola c. 1517 and Vincenzo Galilei, 1568). Could this be indirect evidence of the use of bass roped strings?

In conclusion, considering the historical evidence that roped strings (bumped or smooth: we do not know which) were already in use from the late 15th century, we may ask what really happened around 1565–70, when, in the space of a very few years, more basses were added to the lute as normal practice, something only rarely tried or referred to before. The new open range was enlarged to two octaves, adding a fourth or fifth on the bass side, and at the same time the performance of these all- gut basses became magically so good and powerful and loud. This question is a crucial one: what was that innovative technology?

Conclusion: there is historical evidence that roped strings were already in use from the late 15th century, as a consequence a roped string cannot be considered, as the novelty that permitted the expansion of the lute in the second half of the 16th century,

6) Lute basses: smooth finish or bumped construction?

Only today do we find 'bumped' strings described as historic; all the 17th-century lute sources mentioning lute strings in general, there is no kind of evidence to indicate they were anything but smooth. This is part of the historical evidence one can put forward in answer to Charles Besnainou, the French scholar who considers as historic his hand-made twine bumped rope basses. These he makes starting with a very long, twisted, two-strand string folded in two and then twisted again together in the opposite direction. The two ends of the folded string are left untwisted but only one of these goes through the narrow bridge hole and then is knotted with the other free end on top of the bridge. This would be, in his opinion, the way gut basses were made in past times, presumably by the player directly on the instrument.¹⁴

Here is the evidence we have found about the surface finish of the strings. Mersenne affirms that gut strings were well polished cylinders, finished with the use of a grass with an abrasive property (equisetum or shave grass), but he did not say anything that leads us to believe that this procedure was given only to thin-strings.¹⁵

Il y en a qui n'v'sent point de la veuë, & qui se contentent de l'estafer, & de les manier avec les doigts, qu'ils font courir & couler tout au long de la chorde, & tiennent qu'elle est bonne & esgale, lors qu'ils n'y rencontrent point d'inegalité, & qu'ils la trouvent comme vn Cylindre poly. Mais s'il arriue que ces deux sens se trompent, l'oreille iuge de la bonté, ou de la fausseté de chaque chorde en dernier ressort. Si tost que l'on a rencontré de bonnes chordes, on monte le Luth en cōmençant par la plus grosse, quel'on attache premierement au cheualet par le moyen d'vn nœud composé du droit & du

E ij

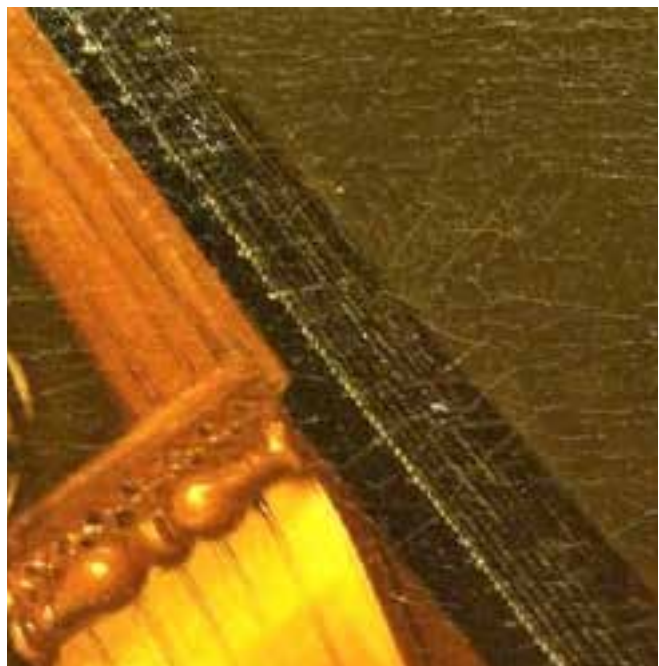
Thomas Mace states clearly that the deep dark red Pistoys (for him the best lute basses) were smooth: "They are indeed the very best, for the basses, being smooth and well-twisted strings. . .". This does not imply, automatically, that Lyons were not. Actually, nothing at all is said about the surface of the Lyon bass strings, (Mace op. cit. fn. 10)

James Talbot says that Violin-Lyons were smooth: 'Best strings are Roman 1st & 2nd of Venice catlins: 3rd & 4th best be finest & smoothest Lyons, all 4 differ in size. . .'.¹⁶

The Mary Burwell Lute Tutor, describing the best strings for the lute ('Romans' for trebles, and 'Lyons' for basses and respective octaves) explains that an important feature of almost all of the strings is exactly that the surface should be well smooth and free from 'knotte' and 'rugged'; Lyons basses were clearly included. (Burwell op. cit. fn. 9)

Mace, in addition, states that the Venice-Catlins for the 'Meanes' were smooth, so when he also states that 'Pistoys' were but thicker Venice-Catlins we must infer that they, too were smooth. (Mace op. cit. fn. 10).

A very accurate painting by Rutilio Manetti (Siena, 1624) clearly contrasts smooth lute basses and the roped metal cittern bass strings.





If the lute basses had actually been bumpy, like the cittern strings, the painter would have done them in a similar way (Mersenne describes roped metal cittern strings: ‘. . . the thickest string of the third or fourth is twisted, and made from a string doubled and bent in two, so as to make fuller tones . . .’).

Conclusion: all our historical evidence points to the fact that the strings, basses included, were smooth, not bumped.

7) Paintings attesting to the pliability and the smoothness of lute gut bass strings

On many of the 17th century paintings (and even later) the lute basses are often represented by the painter as very much thinner than they should be if they were made with plain unloaded gut, and always smooth, not roped (in fact to this day I have not yet found a painting clearly showing roped bass strings):



Jan de Baen, painting of Johanna le Gillon, c.1670, detail

Maybe in this painting there is the evidence of silver-wound bass strings: bass strings are apparently very ‘thin’ and ‘white’ in comparison with the paired clear brown/dark yellow paired octaves. Admittedly in spite of its excellent finish the painter had not quite understood his subject: the bass rider plainly has two strings running to one peg! But presumably he painted the colours, and fall of the strings as he saw them.

In some cases, it is possible to see just how flexible they were (by the way they were knotted at the bridge for example, or even the kind of 'soft' bundle):



Rutilio Manetti, Siena, 1624: detail on smooth bass strings



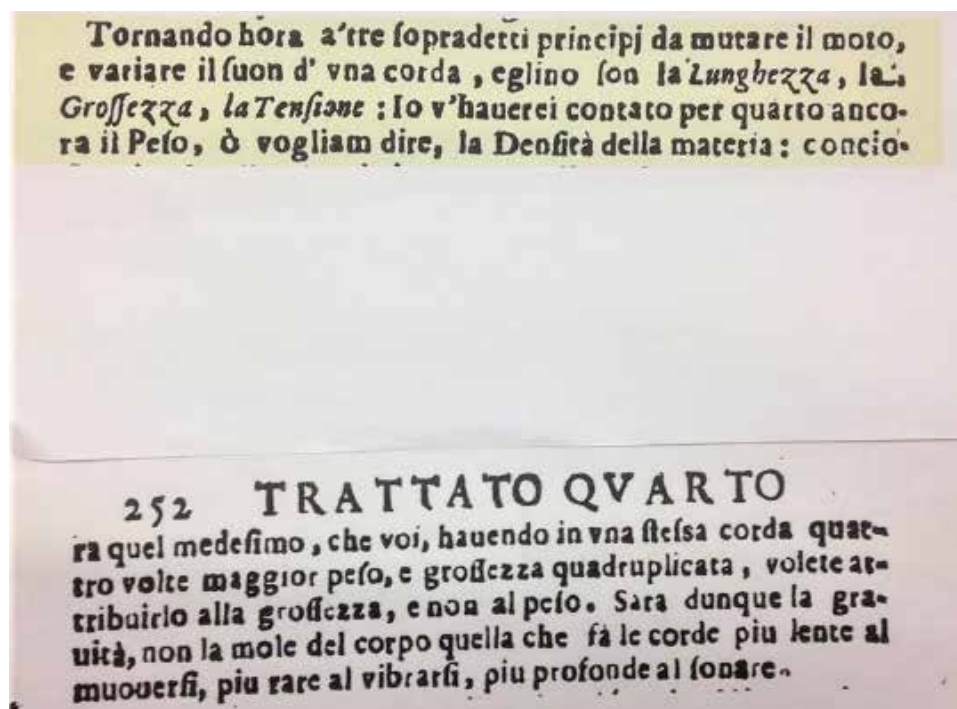
Anonymous 17th century: detail

Conclusion: the old 17th-century paintings shows that lute gut bass strings were pliable, smooth and thinner than what one can expect with unloaded gut strings.

Final conclusion

In order to satisfy all these 7 criteria I was able to find only one explanation: a loaded/weighted smooth roped gut string: the combination between high density and high elasticity is the best way of guaranteeing the best performance in the lower range of Lutes.

There is nothing strange in considering that a gut string can be made denser: we know that the ancients were aware that the density / gravity parameter was an important thing in relation to frequency. Here is Serafino di Colco:



Coming back to the three parameters that can change the frequency and so, able to produce a change in the sound of the string (and they are the length; the thickness; the tension) I would like to count,

indeed, still a fourth (and not just to three) that is the weight, in other words, the density of the material . . . ' (author's translation)

And Vincenzo Galilei explains:

. . . having the same string whose weight is four time more and the thickness the same, you can easily think that it is the thickness and not the weight that makes the frequency lower. The conclusion is that it is the gravity and not the thickness that makes the frequency lower, deeper . . . (my translation)

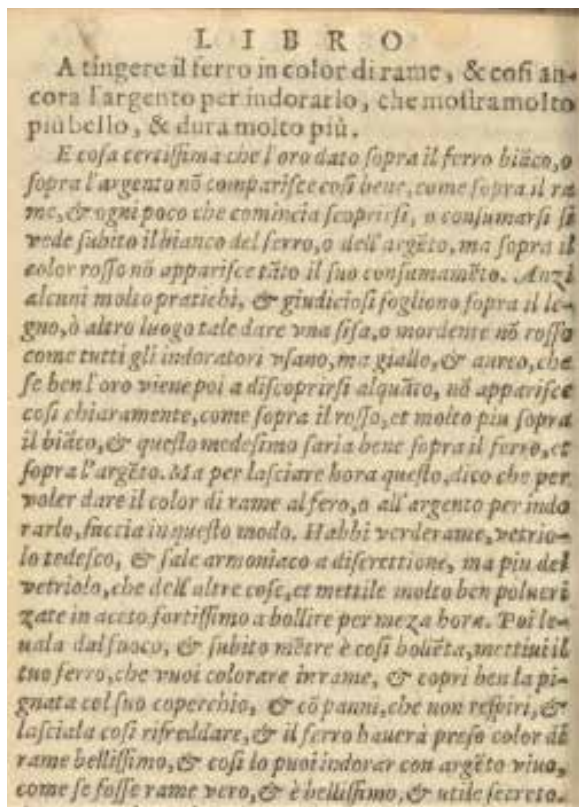
But by how much were the old bass gut strings loaded or made denser? I have a hypothesis: thanks to Virdung, Galilei etc we know that the gauge of an unloaded sixth (roped?) gut string was, more or less, the acoustic lower limit for the sixth course of the lute (i.e., the minimum for inharmonicity). Then we assume that the same gauge should be, again, the limit of the last bass string on renaissance lutes of 7 or 8 or 10 courses (as well as for the 11-course D-minor lutes). This means that there should be an interval of a fourth or fifth down from the sixth course.

Having the same string length, tension, and gauge, and tuned down a fourth, we can calculate that the density of the string should be twice that of natural gut (2.6 gr/cm^3 instead 1.3). This fits quite well even with the bridge hole sizes.

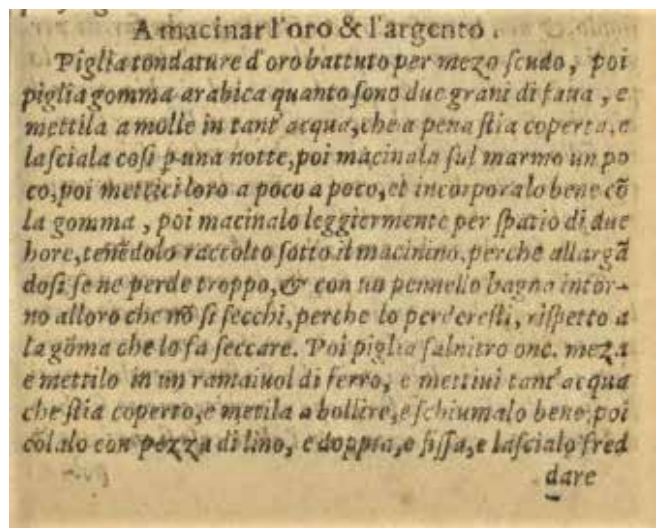
It is interesting to see how the open range of two octaves and a fourth becomes, after the second half of the 16th century, the new limit for lutes as well as for a new kind of bowed instrument: the viola bastarda or 'alla bastarda'.

I have made some practical tests in this matter just to verify what is the upper limit for loading a gut string: I have seen that, actually, it is around twice (or a bit more) that of natural gut. In my tests, I have employed heavy pigments such as red lead, litharge and, finally, fine copper powder: in fact some time ago, I found some recipes of the mid 16th century that explain how to make it and even how to produce fine silver and gold powders. Here are the recipes from Don Alessio Piemontese *I secreti* (Venice 1555).





Copper powder recipe



Silver and gold powder recipe

Any hypotheses that try to explain how the old gut lute basses were made should respect all the seven criteria mentioned above. Any criticism is always welcome but, on the condition, that the alternatives one place on the table can actually cover all of the criteria, not just two or three because all of them come from historical sources.

Objections to the theory of loaded strings, and counter-arguments

Having said that, here are the most common arguments against gut loading theory.

1) Home-made roped strings, or 'split ends' as an alternative, to fit narrow bridge holes

Charles Besnainou ('La fabrication des cordes eten particulier comment répondre aux questions posées par les cordes anciennes', lecture at Corde Factum, Puurs, May 2008) presented the idea of using an ordinary gut string, of sufficient length, of a diameter to pass through a small bridge hole, 'fold' it in half, and then twist it into a roped string directly on the instrument. An alternative would be for the string maker to make the roped string and leave one end open and untwisted, enabling it to be tied with that end on the bridge using some complex type of knot (the string must stay perfectly centred on the bridge in relation to the octave). The resulting string is bumped.

Counter-arguments

This hypothesis simply discards the technically easier solution: why not simply drill slightly bigger holes in the bridge as many lute players who like to play with all-gut basses do today?

Twisting two strings into some sort of D-I-Y rope still requires the strings to be wetted beforehand and then carefully twisted with some tool in a perfectly regular manner: no treatise of the time ever mentions a lutenist needing such a complex know-how, nor that he should employ a long thin string and rope it himself, nor that he should sit still for an hour holding the string's end securely between his fingers waiting for it to be perfectly dry.

Besnainou's theory, if we compare it with the seven criteria, lacks supporting evidence, as does Ephraim Segerman's theory concerning the bumped roped strings: it is interesting enough to remember that the etymological connection between the name 'catline' and a possible nautical term was actually never supported by documents, and then in the 1990s it was refuted by Segerman himself who switched to considering 'Catalugna' as the origin of this name but without any direct evidence.²⁷

This means in consequence that the connection between a roped structure and the name catline or catlin is no longer supported. Actually, these kinds of strings were made in northern Italy (in the Bologna area) and they are mentioned mostly in old English sources; Unfortunately, we do not know what the Italian stringmakers and players called them or how they were made.

Here is a list of what I consider to be the lack of practical and historical evidence.

- a) Can a lute working at 1.0-1.5 kg tension actually work? No. (Try for yourself).
- b) Did a top string of a gauge of 0.26 mm exist? There is no evidence for this at all, for reasons already explained.
- c) Were bumped bass strings ever mentioned in old sources? There is no evidence at all. Whenever this technique actually existed, it was expressly mentioned: Mersenne mentions that the cittern's thicker metal strings were obtained using a long wire, then doubled, bent in two and the two portions twisted together in order to obtain a fuller and better sound—while in the case of gut strings, he wrote that they were made smooth by means of an abrasive grass.

There is a very interesting piece of evidence against the bumped strings hypothesis: Mersenne was clearly aware that a roped string makes a better and fuller sound than a plain string; despite this, he did not mention this practice (i.e. the roped structure) in the section concerning gut strings.

- e) Are modern bumped or indeed 'wet-roped' smooth gut strings are powerful enough to cover the sound of the upper strings? There is no evidence for this at all. Try yourself by comparison with the sound of upper strings, as is mentioned in the old sources.
- f) Were lute gut bass strings bumped roped gut strings made by the player himself or herself using a long 'meane' string, then doubled, bent in two and then the two strings twisted together? There is no evidence for this at all: the sources of the 17th century mention three sorts of strings and all were made directly by the stringmaker: trebles, meanes and basses. This includes all basses. They were called: Lyons, Venice Catlines, Nuremberg basses, 'deep red' Pistoys. (Dowland op. cit. fn. 5; Burwell, op. cit. fn. 9; Mace op. cit. fn.10).

For this theory to be valid, one should expect that only the trebles and mean types would be mentioned. Also one should expect no particular name for the basses, and perhaps even a few explanations on how to make these home-made basses might have survived (maybe with a short description concerning the special tool able to twist the two portions of the string together).

- g) Do any old paintings and/or old documents show or explain this strange method described by Charles Besnainou of fitting the strings into the bridge hole? Again, no evidence at all.

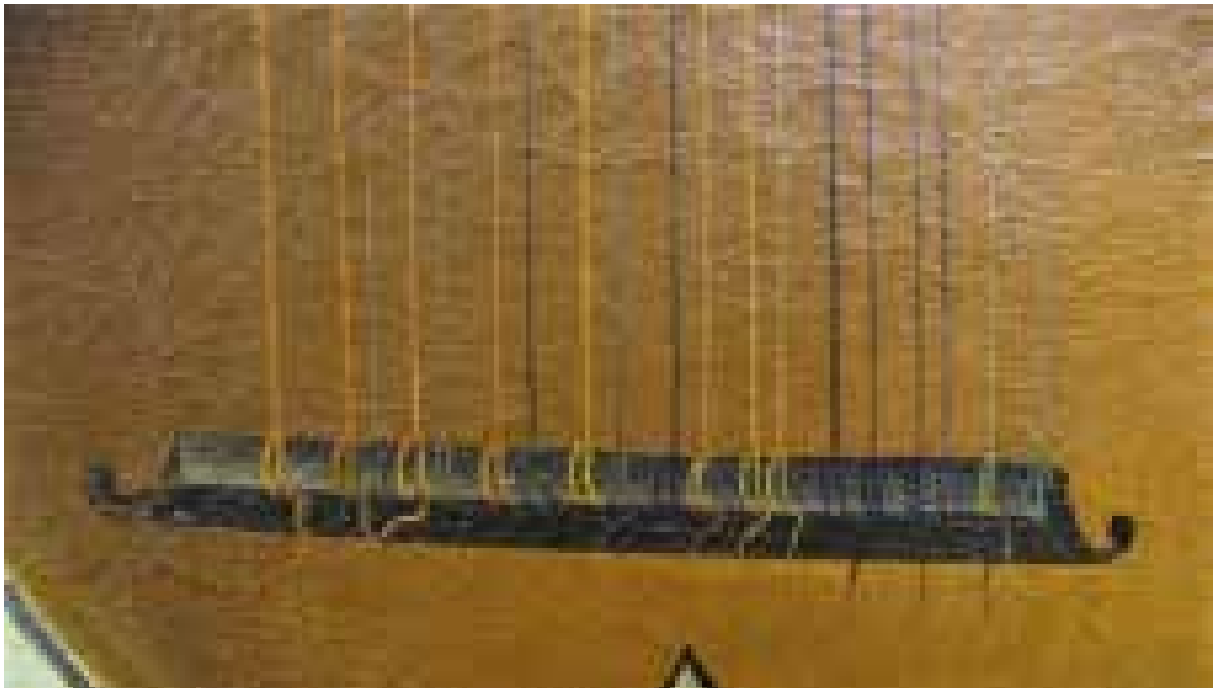
Here is what we can actually see on these few examples—which incidentally show a fine array of coloured strings.



Laurent de La Hyre (1606–1656): detail



Eglon van der Neer, mid 18th century: detail



Bylcius, mid 17th century: detail



Cornelis Norbertus Gijsbrechts, 1659–83

- h) Do the old treatises mention anything about the existence of some special tool for making these home-made roped bass lute strings using very long means drawn into two halves over a hook whose two returning halves are twisted together? No.
- i) Is there any historical source that clearly mentions that the Venice Catlines were made roped or even that there is a link with a nautical term or to a Catalan origin? Not at all.

To continue points used against used against loading theory:

2) No direct evidence or recipes exist from the stringmakers of the past relating to the loading of gut

Counter-arguments

It is true that at present there is no direct evidence related to a process of the loading of gut (a string-maker's recipe; a document that mentioned that the gut of the basses was treated in some way to make it denser, for example).

Actually, no direct information exists at all from the 16 and 17th century string makers concerning their art in general; this is not just true for the bass gut string technology. For example, we do not even have a clear, direct description concerning how roped strings were made by string makers; we just have just proof of the presence of the 'orditori' or ropewalk machines in some 16th and 17th string maker's workshops. The string makers' art was always closely guarded; they did not explain their secrets in books or even in some handwritten documents—or in any form—that would have been available to everybody. There are rather indirect clues and evidence that can give a clear vision of how things probably were done at the time.

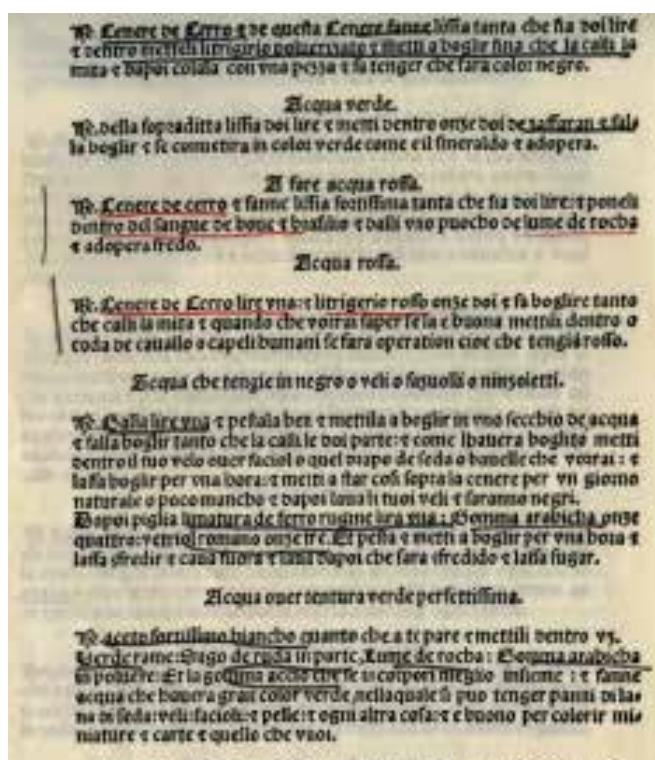
In theoretical terms, here is an example of the importance of indirect evidence: the planet Pluto was known about but not seen directly by a telescope for almost 50 years or more. Despite that, people knew well that it existed through their knowledge of the force of its gravitational effects on the planet Uranus:¹⁸ this is a case of indirect evidence that became direct evidence through calculations, like some of the arguments here, I believe.

Having said that, I would like to point out the very interesting presence of barrels of hide glue in some stringmaking workshops of the 17th century: 'Un barilozzo con dentro libbre 30 in circa di colla cerviona' (a small barrel containing about 30 pounds of hide glue'. Containers with red-dye are also mentioned: of course, we cannot know whether that was employed for dye, or loading the gut. (see Patrizio Barbieri; op. cit 13 p. 97).

Generally speaking I can say that glue was never used in the traditional or even in the modern gut stringmaker's art; instead, it is absolutely necessary, for many good reasons, when one is making loaded gut strings today.

The incorporation of insoluble, mineral pigments into wax, silk, wood, cloth, ink, hair etc may be perceived as very strange today, even though it was a very common practice in those times. So an addition of insoluble thin pigments/thin copper powder on fresh gut ribbons was surely nothing strange for people of the 16th and 17th centuries. To some extent, it is a procedure that was very similar to many of the silk-dyeing processes of those times where they sometimes used to charge this material with heavy insoluble substances.

There are many surviving 16th and 17th-century books and manuscripts, for example, that explain how to incorporate cinnabar or litharge or similar substances into several different materials, such as silk, hair, wood, paper, wax, etc.¹⁹



Recipes from Giovanventura Rossetti's Plichto . . . (Venezia, 1568) book of dyeing recipes

I have said that there is no direct evidence—in the West—related to a process of the loading of gut. However, we have recently discovered a Chinese source that seems to confirm that copper, gold, silver as well as ceramics (etc.) as powders were employed by the old Chinese stringmakers to charge silk strings for the Guqin: this is a direct evidence that heavy substances were employed to charge musical strings; see: <http://www.silkqin.com/02qnpu/05tydq/ty1b.htm#yongyao>

3) Modern loaded strings (and so also those of the 16/17th century) are not transparent or translucent

Some scholars believe that the loading of gut cannot be a real historical option because it would have made the bass strings opaque and not transparent or translucent as mentioned by John Dowland. (op. cit. fn. 5).

Counter-arguments

Any possible mention of transparency/ translucence related to bass strings is limited exclusively to the *Varietie of Lute Lessons*. In fact, in the Burwell Lute Tutor, and treatises of Thomas Mace and Marin Mersenne there is nothing on that subject. In other words, to extend this to include as well the mid-17th century bass gut strings such as 'Lyons' and 'Pistoys' (which Dowland never described), seems to be placing too much weight on one piece of evidence. These are the salient passages:

Now because Trebles are the principall strings we need to get, choose them of a faire and cleere whitish gray, or ash-colour, and take one of the knots . . .

Dowland here says that Trebles are good when they look clear or clear ash-grey but always transparent. Then:

This choosing of strings is not alone for Trebles [first course], but also for small and great Meanes [second and third courses]: greater strings though they be old are better to be borne withall, so the colour be good, but if they be fresh and new they will be cleere against the light, though their colour be blackish.

Here Dowland says that the same criteria employed to check the quality of the Trebles must be applied also to the small and medium Meanes (strings for the second and third courses) that are fatter strings than the Trebles just mentioned before. Then he starts to describe the coloured strings and all the related commercial names, behaviours etc: it is clear that he is still speaking of small and medium Meanes and Trebles:

Some strings there are which are coloured, out of which choose the lightest colours, viz. Among Green choose the Sea-water, of Red the Carnation, and of Blew the Watchet. Now these strings as they are of two sorts, viz. Great and Small: so either sort is pact up in sundry kindes, to wit, the one sort of smaller strings (which come from Rome and other parts of Italy) are bound up by certaine Dozens in bundels; these are very good if they be new, if not, their strength doth soone decay: the other sort are pact up in Boxes, and come out of Germany: of these, those strings which come from Monnekin and Mildorpe, are and continue the best. Likewise there is a kinde of strings of a more fuller and larger sort then ordinary (which we call Gansars). These strings for the sizes of the great and small Meanes, are very good, but the Trebles are not strong. Yet also there is another sort of the smaller strings, which are made at Livornio in Tuscanio: these strings are rolled up round together, as if they were a companie of horse hayres. These are good if they be new, but they are but halfe Knots. Note there is some store of these come hither lately, and are here made up, and passe for whole Knots.

Then, after a full stop he starts to speak about the basses:

For the greater sorts or Base strings, some are made at Nurenburge, and also at Straesburge, and bound up onely in knots like other strings. These strings are excellent, if they be new, if not, they fall out starke false. The best strings of this kinde are double knots joyned together, and are made at Bologna in Lumbardie, and from thence are sent to Venice: from which place they are transported to the Martes, and therefore commonly called Venice Catlines.

Having said that, here are my observations :

- 1) When he introduces the description of the bass strings, there is a clear separation of this from the Meanes, by way of a full stop. There is no description of how these bass strings look. So, any transparency / translucence is related to the Meanes & Trebles only.
- 2) We should not overlook the fact that when he describes a given sort of string, he (like Mace) always uses a capital letter (i.e. Trebles, Meanes, Basses). This is not the case when he mentions 'greater strings', in the above passage, where he is referring to what comes just before the colon (and the colon, when it does not open a list of items, is explanatory, to make clear a concept that has just been exposed), i.e. the Meanes.
- 3) It is worth noting that even an unloaded roped string (the only suggested alternative to the loading of gut), thanks to the high double twisting of the paired strings (which do not have their fibres completely glued to each other so there is always some air enclosed), is in fact opaque and not translucent to light, especially if it is dyed. Actually, the only string that is truly transparent (but only if it is not too thick) is a low twist gut string.

Conclusions

My serious, clear questions are still there: why were all these bridge holes not made bigger? It is not necessary to be a graduate from a university to be able to do this easy job. The most important lute sources wrote that the lute must have the same feel of tension on all the strings: with such narrow holes for the bass strings how it is possible to achieve that (when for Treble, the thinnest whole gut gauge is 0.38–0.40 mm)?

The second question: How it is possible that the old gut lute basses were so loud while ours (roped guts) are so weak?

It is rather hard to understand why some scholars introduce complicated and to some extent illogical explanations in order to avoid confronting such clear and plain evidence: the narrow holes found on all these original lutes and the impossibility of playing at 1 kg (or less) tension; the technical impossibility of producing first strings thinner than 0.40 mm gauge; the very good performance of 17th-century gut basses that are described in comparison with the upper strings etc.

Some explanations, avoiding the loaded gut theory, seem unnecessarily complex or contrived: the hypothesis of the self-made roped strings using one very long Meanes string, twisted in the middle by way of a special tool to obtain a thicker roped string, to me does seem an example of this, unless I have misunderstood something.

A second example of a contrived argument to find an explanation for those narrow bass bridge holes, is the introduction by some scholars of the idea that lutes of the past worked with two different degrees of tension on the same instrument: one very low, for the Basses, and another higher for Trebles and Meanes. This is despite the fact that almost all of the lute treatises of those times wrote that the right set-up is for all the strings have the same feel of tension and that the biggest mistake on lutes is when some strings are stiff and some are slack,²⁰ for instance Thomas Mace (*Musick's Monument*, London 1676):

The very principal observation in the stringing of a lute. Another general observation must be this, which indeed is the chiefest; viz. that what siz'd lute soever, you are to string, you must so suit your strings, as

(in the tuning you intend to set it at) the strings may all stand, at a proportionable, and even stiffness, otherwise there will arise two great inconveniences; the one to the performer, the other to the auditor. And here note, that when we say, a lute is not equally strung, it is, when some strings are stiff, and some slack. (Mace op. cit. fn. 10)

The Mary Burwell lute tutor (c.1670):

When you stroke all the stringes with your thumbe you must feel an even stiffnes which proceeds from the size of the stringes. (Burwell. op. cit. fn. 9)

John Dowland (*Varietie of Lute Lessons*, ed. Robert Dowland, 1610):

But to our purpose: these double bases likewise must neither be stretched too hard, nor too weake, but that they may according to your feeling in striking with your thombe and finger equally counterpoise the trebles. (Dowland op. cit. 5)

Most performers start to perceive a different feel of tension when the difference starts to exceed a semitone of tension. Within that limit they do not perceive any difference; we are in the region of the equal feel of tension. Some players are even more sensitive but they are an exception. The conclusion is that if the bass strings are working at very low tensions, they are clearly perceived by most players as 'slack', uneven with the upper strings: we are far from the so called even feel of tension mentioned by all the 17th-century lute treatises.

In conclusion, the hypothesis that lutes of the past worked with two degrees of tension is not historically sustainable.

What can be an historical alternative to the to the loading of lute bass gut strings? Well, I have often tried to find any other logical explanation but I have always failed: if the bass gut strings are not made denser in some way, the tension becomes dramatically too low to be managed (with a strong increase in pitch and fret distortion); the string becomes weak (while in the historical past they were rather loud); as a further consequence, the first, second strings (within the condition on the equal feel of tension) would need to become too thin for the biology of the sheep. *Vivi felice!*

Appendix 1

Lute strings and their names

Lute strings produced in the 16th, 17th and 18th centuries, unlike today, were identified by names that immediately pointed to the place of provenance, as a clear sign of quality. This particular aspect, in a historical period where copyright did not exist, explains the severity with which the corporations of string makers prosecuted commercial frauds, including string makers within the same corporation if they were caught cheating. Giving the client absolute guarantee that Munich strings were actually produced in Munich remained the highest priority throughout centuries of lute history.

Another point to underline is the manufacturing specialisation typical of different geographical areas: in some regions, for instance, string makers would devote themselves to bass strings, in other regions to treble strings, with astonishing commercial success. Florence (bass strings) and Rome (trebles) are emblematic examples.

This does not mean that Florence produced no treble strings at all, we simply wish to point out that if certain areas gradually specialised in a specific product, it was because they must have found a way to excel in it—be it through the high quality standards, or through new products and more rational and improved methods of production.

Sources from the 16th, 17th and 18th centuries specifically describing the production of strings for plucked and bowed instruments are scanty, particularly concerning the lute, which was the most difficult instrument to string.

Regarding the Age of Enlightenment we have an interesting paradox: at a time when the Encyclopaedists started for the first time to describe in detail the string makers' art (together with some important aspects of stringing for bowed instruments, mandolin and especially 5-course guitar) we know virtually nothing about the lute in S. L. Weiss's time: our instrument had already fallen in a dark corner of history which no Light of Reason could illuminate any more.

Historical sources

15th century

We have no commercial denomination whatsoever for lute strings.

16th century

The earliest mention of different types of strings come from the manuscript of the Venetian nobleman **Vincenzo Capirola** (c.1517): for the first time we have a description of strings of superior quality from Munich (Bavaria); a type of string called 'Ganzer' is also mentioned, whose origin is not quite clear, although it might hint at a roped structure (see below). Unfortunately, Capirola does not specify where on the instrument the strings he mentions were employed.

Another known source is **Adrian Le Roy** (*A Brieve and plaine instruction* . . . London 1574). Le Roy writes that the best strings are those manufactured in Munich (or near it), or in the town of L'Aquila, in Italy: '. . . the best come to us of Almaine, on this side the toune of Munic, and from Aquila in Italie. . . 'After this interesting start he goes on to describing how to tell a good string from a false one. He, too, gives no further information about where on the instrument the strings he mentions were employed. This scanty information is all we have from the 16th century concerning the names and qualities of lute strings.

17th century

The first author who finally throws a bit of light on the question of lute strings is **John Dowland**, in his essay in the *Varietie* . . . of 1610. He divides strings as follows:

—'Trebles': 'from Rome and other parts of Italy'; 'from Monnekin and Mildorpe' (most probably Munich and Meldorf, both in Germany); besides, he mentions other thin strings, 'which &c'.

—Small and Great Meanes: Gansars

—Base: Nuremburge &c. (the best Bases, according to Dowland, are made in Bologna, in 'Lombardy')

In Dowland's work we can see a certain tendency to confusion when describing the Meanes as string typology: it is not quite clear, for instance, whether the smaller strings made in Livorno are Trebles or Meanes, just as it is not clear whether the coloured strings he mentions belong to the Trebles or to the Meanes (or both). Echoing Capirola, he also mentions Gansars.

Next comes **Michelangelo Galilei** who on 6 August 1617, from Munich, wrote to his brother, asking him to get him four thick strings from Florence, for his own and his pupils' needs. Unfortunately, we do not know the commercial name of those strings.

In the **Mary Burwell lute tutor** (c.1670) we read: 'The good stringes are made at Rome or about Rome and none that are good are made in any other place except the great strings and octaves that are made in Lyons att Fraunce and noe where else'.

Here, too, no particular novelties: it confirms what already stated by **Mersenne** (1636), that the best strings came from Rome. What is new, though, is that bass strings and octaves were made in Lyon.

Thomas Mace (1676) is definitely our most exhaustive and valuable source. Like Dowland, he describes three typologies of strings:

- Trebles: top three courses and octave sixth: Minikins;
- Meanes: fourth and fifth and all remaining octaves: Venice catlins;
- Basses: Pistoys and Lyons.

Mace, like Dowland, also mentions coloured strings, but is also not clear whether they were used as Trebles or Meanes (or both).

Romans, Venice Catlins and Lyons appear again in **James Talbot's** manuscript (c.1695), as strings for violin and bass violin.

This sums up all the information we have about string typologies in the 17th century.

18th century

We have no specific terminology about Lute strings.

In conclusion, the names given to lute strings in the 17th century always refer to their place of origin, with two exceptions: Catlins (or Catlines) and Gansars. The former were produced, at least in Dowland's time, in Italy. We do not know what the Italians called them, though. In the 18th century terms like Catlins/Catlines, Lyons, Pistoys etc disappear completely, to give place to a more generic denomination such as: 'strings made in . . .'

All-gut bass strings made by string makers gave way after the second half of the 17th century to wound basses, which were wound up by the lute maker or even, sometime, by the player himself.

Footnotes and bibliography

- 1 Mimmo Peruffo: 'The mystery of gut bass strings in the sixteenth and seventeenth centuries: the role of loaded-weighted gut', *Recercare*, v (1993), pp. 115-51). See: <http://ricerche.aquilacorde.com/i-nostri-lavori/380/appesantimento-del-budello/>: See also: M. Peruffo: 'New hypothesis on the construction of bass strings for lutes and other gut strung instruments', *FoMRHI Quarterly* 62, Comm. 1021 (January, 1991): <http://www.fomrhi.org/uploads/bulletins/Fomrhi-062.pdf>
- 2 Mimmo Peruffo: 'On Venice Catlins, Lyons, Pistoy basses an Loaded- weighted bass gut strings' in *FoMRHI Quarterly* 76, (July 1994) Comm 1288; pp 72–84. See: <http://www.fomrhi.org/uploads/bulletins/Fomrhi-076.pdf>
- 3 Ephraim Segerman: 'On Historical lute Strings Types and Tensions', *FoMRHI Quarterly* 77, October 1994 pp 54–57. See: <http://www.fomrhi.org/uploads/bulletins/Fomrhi-077.pdf>
- 4 The density average of a bumped string is less because its structure is less 'compact' than those of a standard plain gut string. Inharmonicity is the degree to which the frequencies of the harmonics deviate from being multiples of the fundamental: 'a little inharmonicity in the sound changes the timbre in a way that can be considered attractive . . . but increasing inharmonicity reduces the number of audible harmonics (by a phase-cancellation process), which eventually makes the sound too dull and unfocused to be musically useful' (Ephraim Segerman, *Fomhi Quarterly* 104, Comm. 1766) <https://www.fomrhi.org/uploads/bulletins/Fomrhi-104.pdf>. The smooth rather than bumpy texture of a smooth roped string is produced by a 'wet' rather than 'dry' roping method.
- 5 John Dowland: 'Other necessary observations belonging to the lute', in Robert Dowland: *Varietie of lute-lessons* [...] (London: Thomas Adams, 1610), paragraph 'Of setting the right sizes of strings upon the lute'.
- 6 Johannes Tinctoris: *De Inventione et Usu Musicae* c.1487 [my translation from Latin]
- 7 Sebastian Virdung, *Musica Getutsch* (Basel, 1511).
- 8 Vincenzo Galilei: *Fronimo, Dialogo* (Firenze, 1584).

- 9 Wellesley (Mass.), Wellesley College Library, The mary Burwell lute tutor, manuscript, c.1670, facsimile reprint with introduction by Robert Spencer, (Leeds: Boethius Press, 1973), chapter 16 (the first two quotes) and chapter 4 'Of the strings of the lute [...]'.
- 10 Thomas Mace, *Musik's monument* [...] (London: the author & John Carr, 1676), pp. 65-6.
- 11 Mimmo Peruffo: 'Messer Vincenzo Capirola e il segreto per legare le corde del liuto: considerazioni. Attanasio Kircher e i cantini del liuto: test pratici e risultati'. *Il Liuto, rivista della Società del Liuto* (May 2016, pp. 15-25).
- 12 Athanasius Kircher, *Musurgia universalis* [...] (Rome, 1650).
- 13 Patrizio Barbieri: 'Roman and Neapolitan gut strings 1550-1950', *Galpin Society Journal* ix (May 2006); pp. 158, 176-7 Ugolino of Orvieto: 'Declaratio musicae disciplinae' Liber quintus, Capitulum IX: 'De cordarum seu nervorm instrumentalium subtilitate et grossitie'. 1430-40 ca.); he mentions strings 'nervus rotundus uniformiter difformiter'.
- 14 Charles Besnainou: 'La fabrication des cordes eten particulier comment répondre aux questions posées par les cordes anciennes', lecture at Corde Factum, Puurs, May 2008.
- 15 Marin Mersenne: *Harmonie Universelle* [...] , 'Livre Second, Des Instruments', Cramoisy, (Paris, 1636), p. 51.
- 16 M. Prynne: 'James Talbot's Manuscript: IV, Plucked strings. The Lute family', *Galpin Society Journal*, 14, (1961), pp. 59-60
- 17 Ephraim Segerman: 'More on the name "Catline"' *FoMRHI Quarterly* 76, (July 1994), Comm. 1288; pp 85-6.
- 18 <https://en.wikipedia.org/wiki/Pluto>
- 19 Giovanventura Rossetti, *Plichto de l'arte de tentori che insegna tenger pani, telle, banbasi et sede si per larthe maggiore come per la comune* (Venezia, 1568).
- 20 Ephraim Segerman: 'Modern lute stringing and beliefs about gut', *Fomrhi Quarterly* 98, (January 2000), p.59. See: <http://www.fomrhi.org/uploads/bulletins/Fomrhi-098.pdf>

I would like to thank Anthony Hind and Anthony Bailes for their help rereading, commenting, and making some suggestions for the final version of this article.