

From Monofilament Silk Lines to Acribelle Violin Strings.

"Strong silk-threads with the appearance of violin-strings are known in commerce by the name *tengusu*; English, *silkworm-gut*; French *fil de Florence*. In China they are made directly from the spinning glands of full grown silkworms, and have for the same time been used with us for surgical sewing thread, and also in large quantity for fishing-lines (see also *Caligula Japonica*, Butl.)" – Johannes Justus Rein, 1884 (Note 1)

Silkworm gut is a monofilament silk strand made by manually drawing out the contents of the silk sacs of mature silkworm caterpillars. Before synthetic plastic lines became generally available in the 1950's, silkworm gut strands were used by fishermen as transparent leaders to which their fish hooks are tied. Silkworm gut was first advertised for sale to anglers in 1722. (Note 5) Prepared silkworm gut was also used by the medical profession as surgical sutures. The primary source of a superior silkworm gut destined for rod and line fishing came from Murcia, one of the silk producing regions of Spain but other countries with an established sericulture industry such as Italy also marketed similar products that were, however, considered to be less satisfactory by the angling fraternity.

Spanish Silkworm Gut

A detailed account of the preparation of Spanish silkworm gut is provided by A.M.C. Humphries (Note 2). He notes that the sac of a caterpillar (*Bombyx Mori*) can only be drawn to a certain length by the operator dependent upon the judgement of the operator who otherwise has no control over the size and length of the silkworm gut. The drawn gut is sorted into lengths ranging from 7 to 18.5 inches and 9 diameters ranging from 0.009 inch (0.23 mm) to 0.02 inch (0.51 mm). Each gut length tapers from centre to end so is subject to further processing if smaller diameter, perfectly uniform cylindrical gut lengths are required (as for surgical suture applications). This is achieved by passing the gut through holes in a metal draw plate to shave the gut down to the required diameter.

Silkworm gut, prepared the Spanish way for the angling market was, therefore, limited in length. Longer lengths required knotting together shorter lengths. Also the gut was brittle and required soaking in water to soften it before a knot could be tied. The softening procedure did not affect the tensile strength of the gut.

The result of attempting to tie a knot in a sample of dry Spanish silkworm gut (of unknown vintage) can be seen in Fig.1 – the gut cracked when bent and then split longitudinally.

Chinese Silkworm Gut

Chinese silkworm gut was made from the caterpillars of a species of giant wild Saturniidae moth such as *Caligula Japonica*, native to regions of China and Japan and the Far East. Due to the commercial value of Spanish silkworm gut, the Chinese product attracted the attention of the Europeans as a possible lucrative market alternative. The following summary of late 19th C British Foreign Office correspondence provides more information about the gut and its preparation (Note 3).

- The caterpillars do not descend from the tree until they are ready to spin. They are then caught and broken and the silk-gut immediately extracted, steeped in vinegar, washed and drawn out. The operation must be executed without delay – if the worms are kept the gut is useless. Each gut if properly managed will draw out to 20 or 30 feet. The gut is then dried in a shady place then rolled up and considered ready for use. (Swinhoe report to Foreign Office, 1867)
- The silkworm gut drawn from the caterpillar is the sole use to which the creature is applied. For the purpose it is not reared but captured on its descending from the tree to spin its cocoon. The mature worms are steeped in vinegar for a day and then drawn out into gut which is used for fishing lines and for various economical and ornamental purposes. (British Consulate, Amoy, 1867)
- The cocoons of the caterpillar (they are not Bombyx Mori) are worked by the worm into the bark of the tree and are so coarse and thin as to yield silk of coarse texture and in small amount so is unlikely to be of interest to Western cultivators. In this district the Chinese use the worm only for the purpose of making silkworm gut. The true silkworm is only reared here in small non commercial quantities. (British Consul, Amoy, 1867)
- The silk was made from a species of caterpillar that thrives on the 'feng' tree (Liquidambar formosana, Hance) – prepared by throwing the mature caterpillar into boiling vinegar and drawing the silk glands apart to form a thread say, 5 feet long and strong enough to make a line with which to catch small fish. (Kiungechow, 1891)
- In Canton the silk is called 'fish silk' or 'fish head silk'. In Hoihow it is called 'insect silk'. The best silk comes from Hainan in the mountains of the Ling-mên neighbourhood. The male caterpillar produces a single thread of better quality than the double thread of the female. (Kiungechow 1892)
- The gut in China is in considerable demand for making fish lines and seems so strong and serviceable that there should be a commercial use for it in England. Charles Farlow and Co., Fishing Tackle manufacturers, London stated that the Chinese gut tested was very similar to the Spanish gut that was once available years ago but perhaps not quite so brittle. In their judgement it could not be used for fishing purposes and otherwise did not know for what purpose it could be used. (letter to Kew, 1892)
- Exports to Europe from Kiungechow of Chinese silkworm gut for making leaders for fishing lines sometimes amounted to 16,800 pounds. (1892)

So it can be assumed from these reports that the Chinese silkworm gut differed from the Spanish gut in that it was drawn to much greater lengths, was less brittle and was derived from a larger moth of the giant Saturniidae species. The Chinese silkworm gut was also called 'marvello hair'.

Japanese Silkworm Gut

'The moth species – originally from Hainan Island in Southern China – is the giant silkworm (Saturnia Pyretorum Westwood) also known as the Fish-line Silkworm. Indigenous to India, Vietnam and Southern China with a domesticated breeding history dating back as early as the 9th C. The species was introduced to Taiwan (then Formosa) during the Japanese occupation in the first half of the 20th C for commercial production of silk fishing lines for export. The farms were shut down in 1950 (as Nylon lines became generally available) after which the moths spread into the wilderness and are now naturalised' (Digital Taiwan – on line source)

Curiously the Japanese silkworm gut exported for sale internationally immediately post WW2 was not like the drawn monofilament Chinese (or Spanish) gut but was made from multifilament silk thread soaked in a binder to form a smooth and transparent line very similar in appearance to genuine monofilament silkworm gut. According to Humphries (Note 2) the binder was a boiling preparation of animal glue and extract of seaweed (Agar?). In the process the silk reduces to an almost semi-liquid state so that it becomes saturated with the boiling liquid. On drawing off the saturated line is very sticky so is quickly chemically hardened. The most satisfactory proportions of silk filament to glue are 85% to 15%. It is not known when the Japanese invented this type of string.

A sample of Japanese 'silkworm gut' was tested for viability as a lute string – first course, 60 cm vibrating string length pitch f' 350 Hz, 0.36 mm diameter. The string was flexible enough to tie into a knot when dry and sounded promising while being tuned up to pitch. However the string broke about a tone lower than full pitch – equivalent to a string tension of about 2.3 Kg. The break occurred between the tuning peg and nut – the region of highest tension when the string is being brought up to pitch. The breaking load was then separately determined on a test rig as 2.6 Kg equivalent to an Ultimate Tensile Stress (UTS) of about 0.24 Gpa .This value is lower than advertised on the string package (10 lb or 4.2 Kg). Assuming the manufacturer provided a reasonable safety factor for the breaking load (20%?) then the string under test failed at around 50% of the specified UTS. Silk filament is quickly degraded in strength by direct exposure to ultraviolet radiation (sunlight) so this may be the reason for the premature failure of the test string – being stored in a clear packet for around 60 years or so (Note 4). Had the string retained its original strength it likely would have performed satisfactorily as a lute treble string. The binder on this sample was soluble in boiling water.





**Japanese Silk Gut
Fishing Leader - 0.63 mm dia.**



**Japanese Silk Gut Leader
Glue Binder Removed**

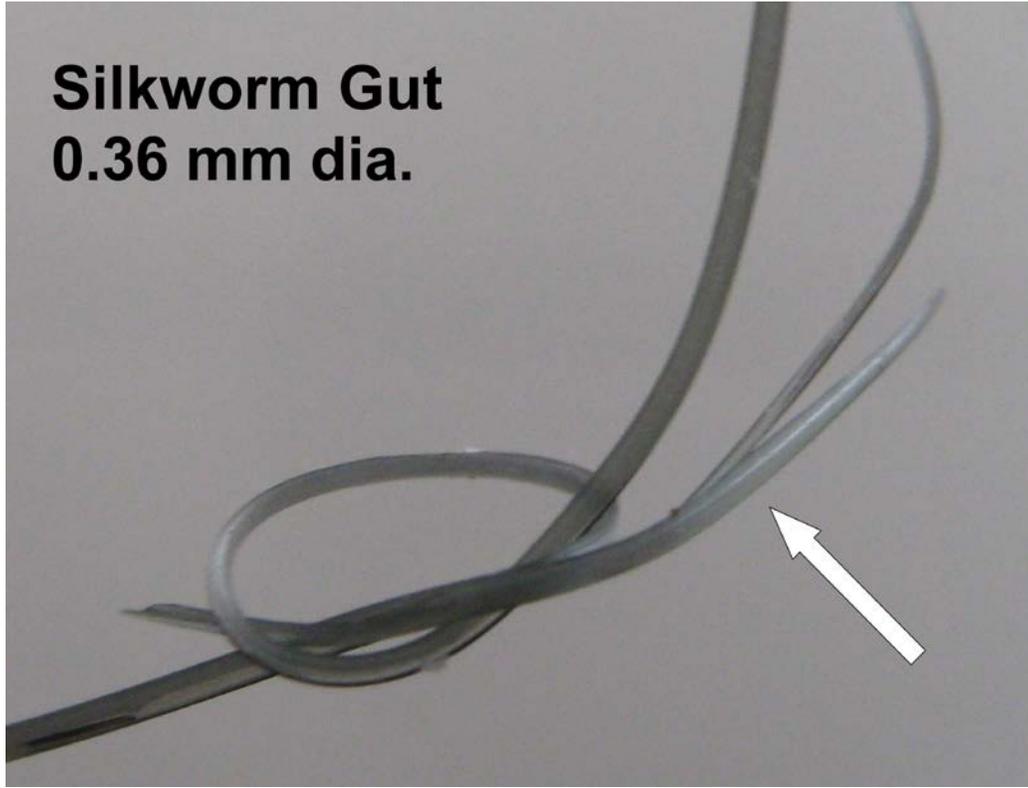


Fig 1 – Spanish Gut Brittle Failure

Acribelle Silk Violin Strings

Although considered by some to be inferior in tone and durability to gut strings made from animal intestines, Acribelle silk violin E and A strings enjoyed popularity in the West for more than three decades from the late 19th C until the 1920's. This type of string was manufactured from silk filament made homogeneous – like the Japanese 'silkworm gut' - with some kind of flexible binder. Advertised as 'Acribelle'- presumably a generic term for similar strings made by a number of different manufacturers?

According to Franz Jahnel 'Die Gitarre und ihr Bau', 1963 these strings were manufactured in Vogtland and Schönbach, Bohemia using processes that dissolved the outer surfaces of the layers of silk filaments to obtain a smooth and shining lustre. However, other manufacturing procedures were also used to make smooth transparent strings of this type – unknown processes because they were never patented.

Notes

- 1) 'The Industries of Japan: together with an account of its Agriculture', 1889 footnote 2, page 196. (free Google ebook). J.J. Rein was a German geographer, professor of geography at the Universities of Marburg (1876) and Bonn (1883)

2) "The Story of Silk and Silkworm Gut", the post graduate medical journal, 1949. (free Google search)

3) As reported in the 'Bulletin or Miscellaneous Information' published by the Royal (Botanical) Gardens Kew, London, 1892, pages 222 to 227.

4) Both nylon and silk filament are subject to degradation on direct exposure to sun light. For example the severity of degradation for a nylon parachute canopy exposed to summer sun is a loss in breaking strength of 52% after 1 week, 71% after 2 weeks and 94% after 3 weeks. The strength loss for the older silk canopies is even greater. For this reason parachutes used by the armed forces are given a service life or limited to a certain number of jumps. The service life for silk canopies was 7 years. Tests on 15 year old silk canopies that were not exposed to sunlight showed that their strength had fallen to below 30% of the original specified value.

5) See Comms 1751 and 1795. Note a typo in the latter Comm ' The silk apparatus of the caterpillar consists of two 15 inch (38cm) long glands ...' should read ... two 1.5 (3.8 cm) long glands ... Some caterpillar!