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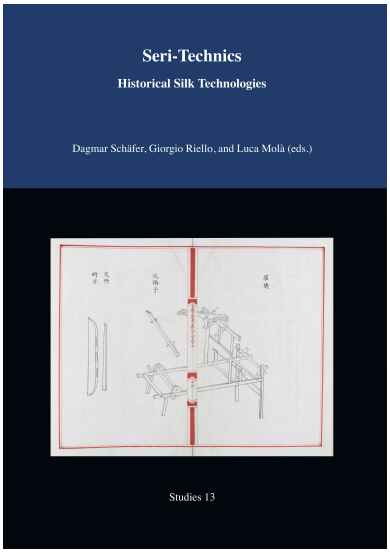
Claudio Zanier:

The Silk Cycle in China and its Migration



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Chapter 2
The Silk Cycle in China and its Migration

Claudio Zanier

Silk cultivation by means of domesticating the *Bombyx Mori* began in China around 4000 BCE, or even earlier.[1] Its migration out of China proper started a few centuries before the Common Era. The technology first headed eastward, towards Korea and Japan, much later it moved westward. This essay deals with the westward expansion of sericulture. Sericulture here is defined as including the operations of raising mulberry trees, harvesting mulberry leaves (the only suitable food for *Bombyx Mori* silkworms), silkworm rearing, harvesting their cocoons and reeling from them the silk filaments commonly known as "raw silk."[2] This chapter does not deal with "wild" silkworms as they have played an insignificant role in most Western silk cultivating countries outside China, apart from some regions in India.[3] The mulberry trees referred to are usually *Morus Alba*, although other kinds of *Morus* such as *M. Nigra* or *M. Rubra*, have been used to feed silkworms in the past. In this essay I argue that the time required to raise mulberry trees to maturity, and problems in ensuring a regular supply of silkworm eggs to rejuvenate silkworm stocks, contributed to the very slow pace of westward expansion of sericulture outside China proper. Moving westwards, similarities in processes are much more striking than actual differences. We can see how beliefs were part of the transmission of know-how, as well as the gendering of sericultural tasks. Significant technical changes only happened when necessity arose in a specific economic and social environment. One example is Northern Italy in the sixteenth and seventeenth centuries, where special silk throwing machines to twist the silk thread, and modified silk reeling machinery, were developed to produce a much more perfect silk thread as required by the market.

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[1] Stone or clay models of various stages of silkworm development, variously dated between 4100 and 3400 BCE have been unearthed in several provinces of China, from Gansu in the north to Zhejiang in the southeast. They appear to be coeval to the world's earliest fragment of *Bombyx Mori* silk fabric, found in Henan and dated to around 3600 BCE. A second fragment, dated around 2750 BCE, was found near Huzhou in Zhejiang province. A detailed, up to date survey of such findings is presented in the China National Silk Museum in Hangzhou. They have been reproduced and/or commented on in Zhao 2005, 12ff and *passim*.

[2] Mankind has attempted for ages to find an alternate food for silkworms with very modest results. At any rate, feeding silkworms with non-mulberry leaves even for a few days invariably lowers more than proportionately both the quantity and quality of silk eventually obtained from their cocoons. *Shengsi* 生絲, (Raw silk, Italian: *seta greggia*, French: *soie grége*) is a fully formed silk thread which might be used as such in the loom. Before the custom of twisting silk threads (more properly: *silk throwing*) was introduced in the early Middle Ages, many surviving ancient silk textiles appear to have been woven purely out of untwisted raw silk threads.

[3] On "wild" silkworms in China, see the chapter by Mau Chuanhui in this volume. Neither shall I deal with "multivoltine" varieties of *Bombyx Mori*, that is, silkworms capable of reproducing several times within a single year. Besides their silk being of much inferior quality, "multivoltine" silkworms thrive in subtropical and/or in monsoon areas (that is, areas regularly experiencing hot and damp summers), such as Bengal or southwest China. Their role in the Mediterranean basin has been minimal. The prevailing *Bombyx Mori* varieties employed in the western world were "univoltine," that is, silkworms that are born in spring, produce eggs after roughly two months of larval life (as "worms") and these eggs hatch in the spring of the following year.

The sericulture section of the silk production cycle has been a rather localized process until recent times. Mulberry leaves can only be transported for a few miles, as they must be fresh when fed to silkworms. Silk cocoons were usually reeled on the spot because, in order to be transported long distances without being spoiled, they had to be most carefully dried using a sophisticated heating process. Such a process was first fully developed during the course of the nineteenth century.[4] Hence silkworm rearing and raw silk reeling were consecutive operations performed in the same area for centuries. On the contrary, raw-silk hanks could travel with impunity for thousands of miles. The length of their voyage was supported by their high value per unit of weight.

Silk textile-making—which in early times must have been performed in, or very near, the place where silk thread was produced—could in later times easily be located far from sericulture areas. Such was the case with the luxury silk fabrics woven in Lucca in the thirteenth and fourteenth century. Lucca's vast raw silk thread input came for the most part (70 to 80 percent on average) from Iran, Central Asia and China. None or very little of it came from Tuscany or any other silk cultivating area in Italy.[5] Similarly, the fabled silk cloths of Byzantium were manufactured for centuries with Far Eastern raw silk, imported via Persian middlemen. Needless to say, a number of sericulture areas also housed their own silk textile industry, for instance, Andalusia.

While the weaving of silk textiles can be performed in any place and in any climate—both Stockholm and Moscow developed large silk weaving firms in the eighteenth and nineteenth centuries—the rearing of silkworms and the making of raw silk has been confined to well-defined geographical areas, that is, areas where the mulberry tree can be cultivated with ease and the *Bombyx Mori* silkworm can thrive. In this sense one can plot a "mulberry belt" stretching across the Eurasian continent. West of China it roughly corresponded to the areas where grapes can be grown.[6] It also broadly corresponds to the inner Asia land trade routes that the nineteenth-century German geographer Ferdinand von Richthofen (1833–1905) first called "The Silk Road."

Two factors limited how sericulture traveled westward. The first relates to the climate mulberry trees need to flourish. The second relates to the belief in the regenerative capacity of the silkworms.

Most of China, particularly south of the Jiangxi river, and coastal East Asian countries such as Korea and Japan, experience high precipitation in late spring and summer due to the monsoon winds. In these conditions mulberries can easily be grown as low bushes that allow abundant leaf picking shortly after planting. Introducing sericulture to a monsoon area

[4] There are a number of documented instances of long-distance trade in cocoons in the late Middle Ages (for example, from ports in present day Albania to Venice). Owing to the primitive ways in which they were dried and stored, those cocoons were hardly fit for proper reeling. They were most likely carded by Venetian artisans, resulting in a thread of much lower quality and value.

[5] Import data from several Lucca trading firms for the years 1284–1314, recently published by Alma Poloni, confirm Roberto S. Lopez's previous research on Genoese imports of foreign raw silk destined to Lucca. Poloni 2009; Lopez 1952.

[6] While mulberry trees may prosper in much colder climates than those that permit grapevine cultivation, the harvesting of all leaves in late spring to provide nourishment for silkworms will harm them. A number of experiments with sericulture in England, Flanders, Moravia, Russia, and elsewhere in Northern Europe failed partly because of the damage suffered by the mulberry trees when stripped of their leaves in cold climates. For England see Feltwell 1990, 72–9, 100–12, and for Flanders see Bonafous 1847; for the Austrian Empire and Russia see Rondot 1885, i, 344–46, 418–19. For specialized literature on mulberry trees, their varieties, and their world diffusion see: de Gasparin 1843, iv–633; Verson and Quajat 1896.

is relatively easy and fast, as the mulberry bushes can produce a vast amount of leaves in a short period, allowing a large crop of cocoons to be gathered.

On the contrary, inner Asia, most Middle East countries, and the countries around the Mediterranean basin usually have a dry period starting in late spring and stretching into summer, often experiencing up to three months with very little rain, if any. Mulberries are therefore better raised as full trees, so that their roots can extend deep into the soil in search of water. Even where irrigation is available, the hot, dry summer climate rarely permits mulberries to be grown as bushes. As a consequence, when sericulture moved westward from China along inner Asia routes, mulberries had to be raised and tended as full-grown trees. When grown this way, leaf picking must be postponed for at least six to eight years of growth before full-scale picking can safely start, any earlier picking will stunt the growth of the young plants. Moreover, the mulberry trees require another twenty years to reach full growth and yield a supply of leaves ample enough to support a voracious horde of silkworms. In other words, expansion of silk cultivation in a new non-monsoon area, where few or no mulberry trees previously existed, required a number of decades before the supply of mulberry leaves was adequate to sustain a viable local silk industry or to export its silk thread in meaningful quantities. In the case of *Morus Nigra*—the variety of mulberry tree indigenous to the Mediterranean and the only one existing there up to the beginning of the fifteenth century—the pace of expansion for new viable plantations was slowed by the *M. Nigra's* limits of adaptation to different soil types, dampness, weather conditions, pruning methods, and the restriction of propagation to seed germination.[7]

The second factor relates to silkworms. It was a common belief in the past—confirmed by practical evidence—that silkworm races first imported from elsewhere tended to "degenerate" in a few years, requiring a fresh import of silkworm eggs from their place of origin.[8] While the degeneration of silkworm assumption is frowned upon by modern scientists, there are plenty of historical documents to support its existence.[9] One such example is the Arab geographer Ibn Hawqal's report that Jurjan (present day Iran) silkworm cultivators imported silkworm eggs at intervals from the eastern oasis of Merv (nowadays in Turkmenistan).[10] Another can be seen in the Northern Italian cultivators' habit of considering Calabrian and/or Valencian silkworm eggs a must to rejuvenate their stocks of silkworms.[11] It appears that the re-import of silkworm eggs from selected places of origin at intervals of every few years in order to rejuvenate the old stock was standard practice almost everywhere, at least up to early eighteenth century. Documentary evidence of such a practice can be used today (with due circumspection) to help identify the sequential chronology of sericulture expansion. Such experimental history though can only speculate how in practice factors such as wars, epidemics, and a host of natural and man-made disruptive elements, may have retarded or complicated the regular rejuvenation of silkworm stocks, slowing down the pace of growth of local sericulture.

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[7] See Verson and Quajat 1896, 181ff.

[8] On the presumed need to import silkworm eggs anew, see: Gallo 1569, 99; Olivier 1599, 58; Zanon 1763, ii–1. Silkworms as such cannot be moved during their lifetime, but their eggs can be transported for long distances, with due care and much attention.

[9] One of the earliest agronomy texts to consider the rejuvenation of silkworm stocks by importing silkworm eggs from afar was unnecessary and even dangerous: Guichard 1786.

[10] See the Chapter on Jurjan in Le Strange 1905.

[11] See Guichard 1786.

Taken together, both factors—raising mulberry trees to maturity and problems with a regular supply of silkworm eggs to rejuvenate silkworm stocks—contributed to the very slow pace of westward expansion of sericulture once it left China proper. As a matter of fact, it took several centuries for a viable sericulture to reach the Mediterranean basin from China.

2.1 The Westward Expansion of Sericulture since the Third Century CE

The first step of sericulture westward from China appears to have been to the Kingdom of Khotan in the modern Chinese autonomous province of Xinjiang.[12] Ancient literary sources testify to silk being cultivated there around the third century CE, and archaeological excavations—first undertaken by Aurel Stein (1862–1943) at the beginning of the twentieth century—also prove that sericulture flourished there in about the third century.[13] After his visit to Khotan in the early seventh century, the famed Buddhist pilgrim Xuanzang 玄奘 (602–64 CE) reported on the earlier introduction of silk.[14] Tibetan texts as well as the Arab geographer Ibn Hawqal confirm the existence of silk cultivation as well as the story of its introduction from China several centuries earlier.[15]

From Khotan, sericulture proceeded westward, with the next documented step being the then vast and rich oasis of Merv (in present-day Turkmenistan), where sericulture was already flourishing by the late ninth century according to Arab geographers quoted by G. Le Strange. There may have been some intermediate milestones on the long road from Khotan to Merv, which have not yet been identified. From Merv, sericulture migrated to the nearby province of Nishapur, in eastern Iran, and from there to the southern shores of the Caspian Sea (proceeding westward from Nishapur to Jurjan to Mazendaran, and later on to Ghilan) and thence to Transcaucasia, where the then Armenian town of Bardaa became one of the most important raw silk production centers in the Middle East for several centuries before being razed to the ground by Mongol forays in the early thirteenth century (see Figure 1).[16]

[12] The capital was at modern-day Hotan (Hetian 和田). The Buddhist kingdom spread from Southern Taklamakan Desert to the Tarim Basin (Xinjiang Province, PR China).

[13] In January 1901 Aurel Stein realized that the fossilized tree trunks he was discovering during his excavations at Niya were mulberry tree trunks. The village of Niya, some 150 km to the East of Hetian, had been destroyed and abandoned in the third century CE, implying that sericulture existed there prior to the abandonment of the place. Stein 1912, i–68. Subsequent archaeological excavations in Xinjiang brought to light used silk cocoons, silk threads, silk making implements etc. For a survey of cocoon troves in Xinjiang see Kuhn 1988, 310–ff. There are more recent updates in Zhao 2005, 12–ff. See also Hansen 2015, 39.

[14] Xuanzang 1884, ii.

[15] Emmerick 1967, 33–35; Ibn Hawqual 2001. Aurel Stein discovered at Dandan Oiliq (to the North-East of Hetian) the fragment of a painted wooden tablet, which might possibly refer to the story of the Chinese Princess who allegedly introduced silkworm eggs in Hetian hidden in her hair-dress. Both Xuanzang (see Xuanzang 1884, 318–19) and the Tibetan text (Emmerick 1967, 33–35), hint at such a princely introduction. Stein 1981, 259–60, with image at Pl. LXIII (D.x.4). See also de la Vaissière 2014, 85–7

[16] The site of former Bardaa is now in Azerbaijan. In the nineteenth century the area around the nearby town of Noukha experienced a flourishing sericulture.

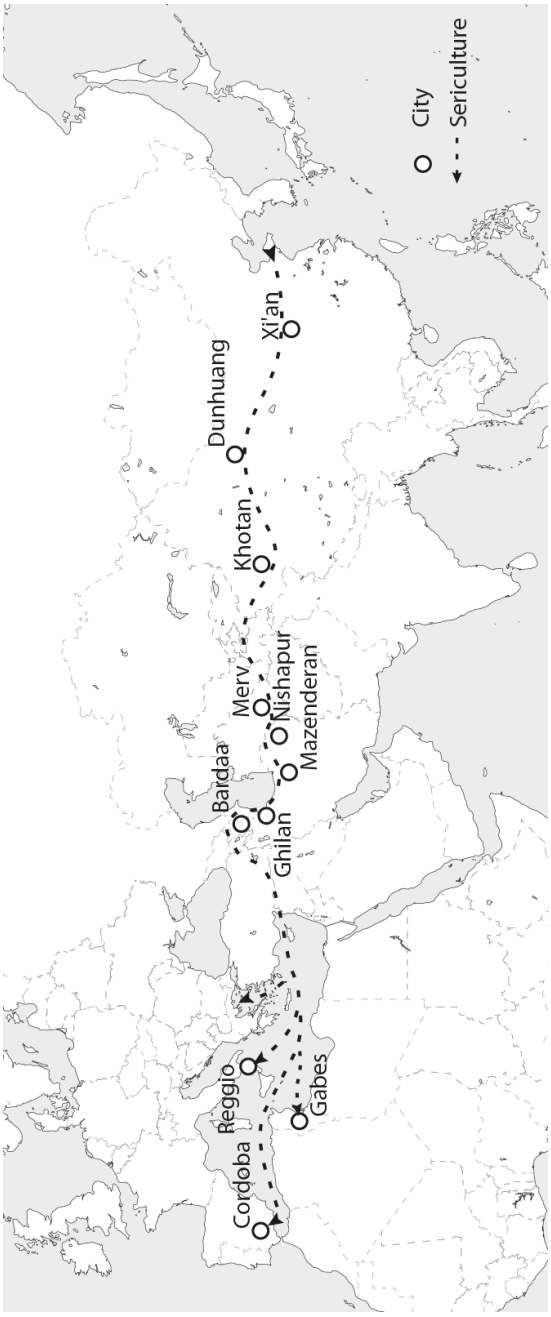

Figure 1: Migration of sericulture since third century CE. Map designed by Wiebke Weitzmann.

Two sets of differing data exist on the arrival of sericulture in the Mediterranean basin. On the one hand, two sixth-century Byzantine historians, Procopius (500–60 CE) and Theophánes (fl. second half of sixth century CE), tell of a bold and successful attempt by a few pilgrims or travelers to circumvent the Persian monopoly on trade in silk thread by directly importing a batch of silkworm eggs into Byzantium from "the faraway land of Seres," which modern historians identify either as eastern Central Asia or, more likely, China itself.[17] The attempt was made during Justinian's reign (527–65 CE) and it somehow crowned various previous unsuccessful attempts by the same imperial court to bypass the Persian middlemen trading raw silk for the Byzantine imperial manufactures either by sea (with the help of Ethiopia) or by land (with the help of Turkish chieftains). On the other hand, the earliest documented proof of actual large-scale sericulture in the Mediterranean comes from the so-called "Cordoba Calendar" (from mid-tenth century) and from a twentieth-century discovery of a parchment related to Calabria on the southern tip of the Italian peninsula (early eleventh century).[18]

Although many modern historians affirm that the reported introduction of sericulture in the times of Justinian freed Byzantium from Persian intermediaries once and for all, and rendered the Empire autonomous in regard to silk thread (raw silk) production, there is not a single piece of evidence to support this assertion for the three to four centuries after Justinian's reign. For one thing, apart from one indirect quote in the eleventh century, no Byzantine historian after Procopius and Theophánes ever refers to the attempt.[19] Indeed no historical documents support the claim that before the ninth to tenth century raw silk was produced within the boundaries of the Byzantine Empire. Given the scarcity of sources the issue will remain highly debatable, with the validity of Procopius and Theophánes' reports having been called into question, too.

My educated guess is that if the Procopius-Theophánes story is true (and I believe it is), either the early sixth-century attempt to install sericulture in the Byzantine Empire failed miserably, or, if it was successful, did not take off as expected and perhaps limped along for decades or even longer with few products of low quality. The very fact that the silk fabrics of Lucca, which had begun their swift ascent in Europe by the late twelfth century, did not make use of more than trifling amounts of Mediterranean raw silk until the thirteenth and fourteenth centuries, suggests that it did not meet the quality requirements of luxury silk fabrics. One should note that earlier Byzantine woven silks were much pricier than those of Lucca, hence their quality requirements must have been all the higher.

A highly fascinating documentary source such as the early medieval Cairo Geniza papers, painstakingly perused and analysed by the late Shelomo D. Goitein (1900–85) may add some interesting details, although the validity of dating through those parcelled fragments is in many cases questionable.[20] A few references to a limited trade in raw silk emerge from them, and one might state that a few places in Sicily, in Tunisia (Gabes), and on the shores of Syria did produce some medium to low quality raw silk in an unspecified period earlier than the tenth century. If anything, the data reinforces the hypothesis of some marginal

[17] Haury 1905, 576–77; Dindorf 1870, 446–49. On "seres" see: Plinio il Vecchio (Pliny the Elder) 1997, 54.
[18] Dozy 1961; Guillou 1978. In the former document silkworm rearing is cited as a regular source for fiscal dues; in the latter, the parchment states that the Bishop of Reggio Calabria was entitled to a fee from those picking mulberry leaves from a large number of mulberry trees growing within his domain.
[19] Zonaras and Pinder 1897, iii–72.
[20] Goitein 1967a, 6 vols., see particularly for Sicily and Tunisia silk, Goitein 1967b, 222–224. See also: Goitein 1971.

sericulture scattered here and there in the Mediterranean basin on the eve of the take-off of large-scale sericulture in Andalusia and Calabria. It is highly likely that by the eleventh century a few areas in the Hellenic section of the Southern Balkan Peninsula might have achieved a significant level of raw silk production too, both in terms of quantity and quality, although firm evidence of the scale of operation is still lacking.[21]

Be that as it may, once sericulture eventually took off in the Mediterranean basin, it never stopped expanding.[22] In the course of the late Middle Ages, the Italian peninsula overtook the Iberian peninsula in raw silk production and while the latter somewhat retrenched after the fall of Granada in 1492—and above all after the rebellions of Morisco silk cultivators in the late sixteenth century—the former expanded even more rapidly. Once the main regions of northern Italy (Piedmont, Lombardy, the Veneto) joined the mulberry planting frenzy of other areas of the peninsula, Italy became the main producer of raw silk in the Western world. From the seventeenth century onward most Italian states saw a gradual reduction of their role as exporters of highly prized silk textiles—as they were matched and superseded by French, English, and later on German and Swiss competitors—but they simultaneously experienced a rapid growth in their international role as exporters of quality raw and thrown (twisted) silk. By the mid-nineteenth century, Italy was the leading world producer of silk thread after China. But by the early twentieth century, it had lost its runner-up status to Japan. Silk products (mostly threads) continued to be the first export item (in value) of the Italian peninsula for the entire nineteenth century and up to the Great Depression of the 1930s.[23]

Having broadly outlined the centuries-long journey of sericulture towards the west after leaving China in or around the third century CE, it may be helpful to note that various kinds of silk fabric manufactured in China and perhaps also in neighbouring Central Asia, had already reached the Roman Empire long before the westward journey of sericulture begun. It is well known that some Roman intellectuals were deeply worried by the fashion craze induced by the new exotic textile products, both because their thinness hid nothing of the bodies of the ladies who wore them and due to the apparently outrageous sums spent on their purchase. The recent finding of dozens of Chinese silk fabrics fragments in the tombs of Palmyra bear witness to a rather diffuse use of imported silks, even among the wealthy provincial elite in the first centuries of our era.[24] In the following centuries and even after Middle Eastern states and the Byzantine Empire had developed their own silk textile manufacture, Chinese silk fabrics continued to arrive in the West, influencing dress, fashion, and cloth patterns, but also how looms were used, and how warp and weft were set.[25]

Soon after Chinese silk fabrics first made their appearance in the Roman Empire, silk thread followed. By the fourth century CE, raw silk from China or Central Asia was already common in the Eastern provinces of the Roman Empire.[26] Seen in perspective, silk came to

[21] David Jacoby has devoted much of his scholarly research to silk production in the Hellenic area in Medieval times. See, among other contributions, Jacoby 1991; 1994.
[22] Dini 1993; Jacoby 1999.
[23] ISTAT 1959.
[24] Liu 2010, 27–8.
[25] Personal communication, Prof. Sophie Desrosiers, EHESS, Paris (Seminars 2007–2008).
[26] See Homily VIII of Basilius Magnus (B. Caesariensis), composed around 377 CE, where he refers to the precious threads provided by "Seres," from which the local women Basilius preached to used to weave soft garments. Di Cesarea 1990, 264–67.

Europe in a reverse order with regard to its production process: first silk fabrics, then silk thread, and finally sericulture and the silkworms themselves (by way of their eggs).

2.2 Sericulture Transmission: The Similarities of Customs and Beliefs

In examining the technical aspects of sericulture transmission, one would expect that the length of the journey, both in terms of geographical distance and the number of centuries it took to reach Europe, together with the lack of direct contact between the two terminals would have resulted in technical divergences in the execution of the process as well as in the instruments employed. In other words, while moving westward and settling in successive areas with different agricultural and manufacturing traditions over a very long span of time, the process itself, or at least some important sections of it, might have evolved along different lines. Instead, similar, at times identical, technical practices seem to be the rule rather than the exception. As a matter of fact, some of the exceptions are quite interesting and one or two deserve close examination in light of the technological competition between Chinese and Western manufacturers on the eve of the Industrial Revolution. I shall deal with those further on. The focus here is on the far more numerous similarities.

One might rightfully expect that sericulture, having been exported from China some seventeen centuries ago, would have experienced a wide evolutionary change in the course of its adaptation to the Western world. Instead, Europeans who visited China from the sixteenth century onwards perceived the Chinese origin of sericulture: many technical aspects of it were quite identical in the two areas, particularly so in silkworm rearing practice. It appears that the two sericultures either developed in tandem or changed very little over time. If anything, European reeling instruments were somewhat clumsier than most of the Chinese ones, with the only exception, at the end of seventeenth century, of the new Piedmont reeling machinery and of the related water-powered silk-twisting mill.[27]

Starting in the mid-eighteenth century and continuing, with increased frequency, into the early decades of the nineteenth century, Europeans (especially the French), baffled by the low cost and high quality of Chinese silk products, began sending experts—industrial spies—to China to study and possibly acquire the technical "secrets" of Chinese silk production.[28] They came back almost empty-handed, apart from marginal details and processes which brought no radical change to the way sericulture and silk industry were practiced in the West.

As already mentioned, most silk-making machinery and instruments to be found in China, particularly those used in the various stages of silk thread manufacturing and refinement, were very close to European ones in concept as well as in design. Silk reeling at the end of the eighteenth century was a pretty sophisticated and quite efficient process, compared to the ancient methods peasants used to spin cotton and manufacture cotton threads. While mechanical spinning of cotton first took place in Western Europe in the second half of the eighteenth century—and was one of the leading components of the industrial revolution—it was not until the 1830s, by applying advanced metallurgy and steam technology,

[27] For an overall, detailed view of silk production in Piedmont (Italy) see: Chicco 1995; for the role of the non-Chinese hydraulic silk-twisting mill in Italy see: Poni 1972; for a technical survey of the hydraulic silk-twisting mill see : Crippa 1990; for a comparison of Piedmontese silk reeling and silk-twisting instruments to Chinese ones see: Zanier 2005.

[28] Zanier 1988. For earlier (seventeenth and eighteenth century) attempts see: Zanier 2005, 12–18.

that silk-reeling in selected areas of Western Europe began distancing itself from the older model of Chinese design.

One may infer from the above, that Chinese sericulture at the time it started its journey to the West was a fairly advanced production and had already evolved in China by way of successive refinements and trial-and-error procedures for a very long period of time.[29] Sericulture was particularly suited to being introduced to an equally advanced agricultural and manufacturing environment. Whenever this was not the case, sericulture adapted to the new circumstances by "lowering" its technical standards.[30] Improvements would only come if there was a sharp evolution of the overall economic and social environment. As we shall see later on, fast growing European demand for high-quality textiles in the thirteenth century and a similar, albeit on a much larger scale, increase in demand in the late seventeenth century, brought about the only two significant basic non-Chinese innovations to the way silk thread was made in Europe, that is the introduction of the giant hydraulic silk-twisting mill and the modifications in the manufacturing of the silk thread in the reeling instruments (the latter being first applied in Bologna and then in the whole of Piedmont). Coupled together, as they were in Piedmont from the 1670s onwards, these two innovations in reeling and twisting resulted in a product (the *organzine* twisted silk thread) that was one of the very few manufactured items, perhaps the only one indeed, to be decidedly superior to equivalent Chinese ones in textile making before the Industrial Revolution.[31]

2.3 Beliefs as Part of Know-How

To the surprise of European nineteenth-century silk experts touring the Eurasian continental areas where sericulture was practiced, the "superstitions" and "false beliefs" they found there were very similar to those that infested, in their positivistic view, European silk cultivators.[32] These included ways to prevent silkworm nurseries from being hit by the "evil eye" or from other natural or supernatural evils. Several proverbs and various habits, concerning both silk and silkworms, may be added.

Western literary sources of the Renaissance period, such as silkworm rearing manuals and poems dedicated to silk-making, show traces of mythology and rituals which, under their Classic garb, bear striking similarities to ancient Chinese myths and rituals linked to mulberry trees and silkworms.[33]

Sericulture must have traveled to the West as a comprehensive set of know-how. That is, state-of-the-art techniques were inextricably linked with what our forefathers would have

[29] Once all the stages of silk cultivation from China to the West were settled, constituting a sort of active "sericultural belt" from Xinjiang to the Mediterranean basin, there is no reason to assume that a number of further details and innovations might not have flown from China towards Europe along that route. Contributions of the sort are likely to have taken the sea route from China to Europe as soon as the Cape route was opened, too. The striking similarity between silk reeling machinery still employed today in the Canary Islands with analogous Chinese machinery could well be one example of the latter point.

[30] Such was possibly the case with silk looms. Chinese looms were far more advanced than European ones up to late Medieval age: silk-looms à-la-tire began being used in Europe around the late thirteenth to fourteenth century while similar Chinese model looms have been recently excavated in one tomb of the Han dynasty period (206 BC–220 CE). Similarly, before innovations in Piedmont and in Bologna on silk-reeling instruments in the seventeenth century, most instruments used in Europe were much clumsier than Chinese ones, although identical in basic design.

[31] For technical details on these innovations see Chicco 1995, and Zanier 2005.

[32] Fortune 1857. Castellani 1860. The latter book has been translated into Chinese and English: Castellani 2016.

[33] Most importantly Vidae 1527, which was translated into several European languages. It served as a model for silkworm manuals for the following two centuries.

called a bunch of superstitions. From this perspective one may better understand why, until quite recently, silk producing countries across Eurasia kept up so many of the ritual aspects of sericulture. A delicate and fragile process such as the rearing of silkworms could only be accomplished through the careful, learned, and trained use of an entire set of knowledge which included, to give one example, knowing how many times a day to feed silkworms as well as knowing how to dispel the evil eye of a hostile person. Both types of knowledge were deemed equally essential for the well-being of the insects.

In pre-industrial times, the technical aspects of a production process were just a section of a complex whole, made up, among many other things, of know-how, individual skills, instruments, social roles, beliefs, rituals, cults and myths. There could be no question of knowing how to apply only one, ignoring the other.

As late as the 1930s, silk workers of Bukhara considered their precious instruments passed down from father to son, and from mother to daughter—as sacred objects to be preserved and revered. Much of their income as well as their standing among their fellow artisans depended upon these instruments. When one implement broke, the fault was invariably attributed to an evil act by some individual enemy or by an evil spirit. The broken pieces were never thrown away but carefully saved as a talisman to protect the artisan's family.[34]

If the concept of a comprehensive know-how, necessarily including "techniques" (as understood today) and "beliefs" holds true, and many details point to it, then it is a logical consequence that the journey of sericulture from China to the Mediterranean could not have been accomplished by simply passing along, stage after stage, a set of technical instructions to interested strangers who would have then applied them once back home. Either instructors themselves moved to the new location with their whole baggage of knowledge and instruments, or strangers had to be admitted into the local silk workers community and work there as apprentices for very long periods of time before moving elsewhere. So the migration of sericulture westward would have depended not only on silk worm eggs and mulberry trees, but also on the migration of the learning of a highly specialized knowledge.

Indeed, when Britain tried to circumvent the world monopoly on "organzine" silk thread held by Piedmont around 1720, it first "obtained" (stole?) the blueprint of the most advanced silk throwing machinery, and built giant copies of it in a huge industrial building at Derby. The experiment failed miserably as neither the necessary prerequisite set of preceding steps (silkworm rearing, cocoon sorting, careful reeling on innovative machinery etc.) nor skilled workers who knew the process were imported together with the plans for the machinery.[35] Having learnt this lesson dearly, all later attempts to transplant the Piedmontese model and the establishment of sericulture implied the recruiting in Italy or in France and transfer of skilled workers to the new locations. Two examples are the early attempts at silk production in the British colonies of North America as well as the transfer of scores of mostly Piedmontese silk-reelers to Bengal from 1769 onwards. A similar attempt was made after 1778 in the northern Portuguese province of Tras-os-Montes, again with Piedmontese

[34] Reported in Gibbon and Hale 1997, 65. Ampler details on Central Asia silk workers beliefs in: Tursunov 1974, 150–71.

[35] The story of the Lombe brothers who allegedly worked in disguise in a silk twisting (throwing) mill close to Turin to learn how the machines were made and how to work them and then got a huge Government subsidy to build the Derby silk mill—considered by many the first plant of the Industrial Revolution—has been a *pièce célèbre* in economic history manuals since Paul Mantoux dealt with it in his Mantoux 1906. The story has been moreover popularised and romanticised to the extreme. A neat reconstruction of it based on archival and contemporary sources is to be found in Chicco 1995.

technicians.[36] It must be added that all of these attempts were only partly successful, if at all, perhaps because the socio-economic environment in which they were made was wholly different and/or much less advanced than that which had allowed Piedmont to significantly innovate on the highly effective silk making model it had inherited from China.

2.4 The Gendered Nature of Silkworm Breeding: Women in Sericulture

A further striking similarity between all non-Chinese sericultures and the original is the role of women. Wherever sericulture has been practiced it was women only who reared silkworms. As a matter of fact, the whole silk production process was originally in the hands of women.[37] Such was definitely the case in China since the remotest antiquity. According to the classical text *Zhou li* 周禮 (*Book of Rites*), which documents the ceremonies and rites of the Zhou dynasty around tenth century BCE, the very first duty of an Empress was to take care of silkworms, to superintend silk weaving and to settle the terms for pricing and selling silk products in the special markets of the capital city that were under her exclusive control. A number of complex rituals accompanied each stage of her duties.[38] Jean-Pierre Diény has gone even further by examining ancient Chinese peasant poems that were collected in classical texts a few centuries BCE but which had been passed down orally for generations. He underlines how in pre-historical times women made use of mulberry tree groves, which were under their full control for silkworm rearing, as places where collective ritual mating took place under their initiative.[39] In Chinese tradition, individual mulberry trees or mulberry groves placed near rivulets became symptom and synonym of fertility rites. They had a highly relevant position in myths, legend and rituals, as reflected in several passages in ancient classical literature. This is also shown by the very high status given to silkworm care by the Empress herself.[40] In this context women in general—and the Empress most of all—had a sort of "catalyst" power to start fertility cycles. After silkworm rearing, the next main duty of the Empress was to personally perform rituals that would grant fertility to the carefully preserved agricultural seeds that the Emperor would sow soon after.

The first step in caring for silkworms is the hatching of their eggs. It requires a high degree of attention, first because those tiny eggs are to be handled most delicately, second, and most importantly, because they must be brought to hatch in perfect accordance with the budding of mulberry tree leaves, which is often unpredictable due to the vagaries of spring weather. Were the eggs to hatch before the leaves sprouted, there would not be any food

[36] For more on all three examples see Chicco 1995. In 2004, Roberto Davini submitted a PhD dissertation prepared with the use of original archive materials from Calcutta dealing with the impact—technical, social and economic—of the prolonged experiment of the transplant of Italian silk making practices in Bengal in the latter part of the eighteenth century. Davini 2004.

[37] To dispel the doubt readers may have that women were connected with sericulture simply because it was low paid labor, it must be stressed that up to the early nineteenth century, silk-reeling women were often paid more than men on an hourly/daily basis, and that profit from cocoon sales was quite often the personal income of women only, not to be shared with the rest of the family. See Zanier 2007; Zanier 2010.

[38] Biot 1851, see especially vol. 7, 140 ff.

[39] Diény 1977.

[40] Beside Confucian classics, several passages in *Shanhaijing* 山海經 and *Soushenji* 搜神記 as well as in several more texts composed during the Han dynasty (206 BCE–220 CE) or shortly after, deal with the mythical role of mulberry trees or silkworms, both invariably connected to women, to supernatural powers, to extraordinary events or to the birth of exceptional persons. Rémy Mathieu suggested that in Chinese mythology "la métamorphose de la larve du bombyx occupe une place centrale." Fracasso 1996; Gan 1966; Mathieu 1983, xli.

for the new born insects, spoiling the crop entirely. It was therefore necessary to attentively guide the hatching by applying moderate heat at the appropriate time only. Once eggs are heated, it is impossible to stop the process of hatching.

All over the world it was the female body that performed this delicate and strategic task. At the proper time, silkworm eggs were gently wrapped in a piece of white, clean cloth and placed between a woman's breasts for two to three days to hatch. This procedure is quoted in Medieval Arab texts relating to sericulture in Morocco, Iran, Egypt and elsewhere in the Muslim world.[41] It is to be found in a brief fourteenth-century Byzantine guide to silkworm rearing (by Manuel Philes) and it is universally quoted in European manuals from the fifteenth century onwards.[42] Travelers met with it in nineteenth-century Iran, Central Asia, Anatolia and China. Eighteenth-century agricultural reformers in Europe considered the practice obsolete and dangerous. Nineteenth-century agronomists saw it as an unhygienic, antiquated and irrational habit, proof of peasant backwardness. Special hatching machinery was devised and amply publicized in order to eradicate a habit that moralists too were beginning to view with disdain. Yet even today, older people in former sericulture areas of China, Japan, Italy, France, and Spain might remember their mothers or their grandmothers telling of having seen or practiced this custom with the utmost care.[43] The persistence of the practice, unabated for centuries, together with its diffusion at a world level among people of different creeds and with different attitudes towards the use of the human body tells of a strong root in ancient rituals. Italian manuals of the Renaissance tell of the "special" warmth of the female body, which alone could guarantee the optimal outcome of the process. One of the founders of modern entomology, Ulisse Aldrovandi (1522–1605), a most rational scientist in all his writings, maintained that silkworm eggs could be made to hatch by other heating methods *sed felicius nascuntur* (but they hatch best) when kept between a woman's breasts, his *felicius* implying that the worm will thrive after this treatment up to the cocoon spinning.[44]

Indeed, the process had taboo overtones. In telling of different heating methods, mention is made of places such as under the pillow or under the mattress at night, or close to the fireplace, etc. But to my knowledge, there is no mention that hatching might be performed by men. In most cultures, men were on principle strictly excluded from the process of silkworm rearing or even from the room where it took place. As late as 1910 in a large farm near Mantua in Northern Italy the woman (a peasant) in charge of the silkworm nursery would allow one pre-pubescent male child to enter the place as an exception; adult males, including the powerful farm owner, were definitely barred.[45]

The role of women in charge of silkworms was explicitly equated to that of mothers caring for their children. In order to achieve the best possible outcome they had to be young, healthy, and plump. One sixteenth-century Italian manual on silkworms states that old women too could, when needs must, look after the hatching of silkworms. In this case the

[41] Kazwini 1805, 39; Renaud and Muḥammad Ibn al-Bannā 1948, 34; Muhammad ibn Musa al-Damîrî 1906, 794–95.
[42] Lehrs and Dübner 1846, 68; Della Cornia 1982, 278; Magino 1588, cciii.
[43] Candiani 2000, 31 (the author witnessed the practice in his own family in the late 1940s); Giuseppina Bonelli of Saluzzo (Piedmont, Italy) witnessed the practice by her mother in the 1920s and 1930s (personal communication, Saluzzo, June 1993). For Romania see Murgoci 1928, 251.
[44] Aldrovandi 1602, 286.
[45] Personal communication by prof. Giovanni Tassoni speaking of his own experience in Viadana (Mantova, Italy).

heat of fireplace was to be employed, not their cold, useless bosom.[46] Chinese texts as well as silkworkers called the woman who superintended the nursery the "mother of silkworms" (*canmu* 蠶母).[47] Traces of women-centered fertility rites performed to ensure successful silkworm rearing can be detected in sixteenth-century literary sources on European sericulture too. These practices certainly fell under the axe of the Counter-reformation, but may well have gone underground.[48]

Women, with a few exceptions, have been considered the most apt choice for reeling quality silk threads from cocoons. Since the Middle Ages, expert silk-reelers were known in Italy by the reverential title of *maestre* (masters), a title only granted to qualified senior artisans. In many Italian towns, guild regulations imposed several years of controlled apprenticeship to silk-reeler women before they could be recognized as *maestre*. They usually were women in their thirties or even older. Much younger girls, in most cases their own daughters or younger relatives, were employed in menial jobs such as turning the reel by handle or minding the fire under the basin where cocoons were immersed. Watching and listening to their mothers and female relatives perform the skilled tasks formed a "de facto" apprenticeship that preceded the guild training. At the same time it kept the transmission of know-how within (female) family lines. Technical literature abounds with warnings to those who would like to invest in the trade that no good silk could ever be produced without skilled *maestre*.[49] Expert women in the field might receive pay higher than that of men with equivalent duties. The privileged role of *maestre* first began to decline with the industrialisation of the silk production process after the mid-nineteenth century. However a number of specialized, delicate tasks required the dexterity of female hands until the early twentieth century.

As already mentioned, women in China appear to have controlled the whole silk-making cycle since antiquity, including the actual property of most of its products. There are few scattered indications in the late Middle Ages and up to the sixteenth and seventeenth century that in Europe too women were seen as the sole owners of some of their silk products, such as cocoons and, possibly, the raw silk they had reeled themselves. There are also signs of an early gender conflict in the case of the natural resources needed for silkworm rearing. Pietro de' Crescenzi (1233–1321) from Bologna, writing circa CE 1300 in one of the earliest post-Classical agricultural manuals in Europe did not mention silk cultivation at all although he devotes some time to mulberry trees, both for their succulent fruits as well as for their medical uses. However he complained about "le troppo moleste femmine" (those very troublesome women) when they pick leaves from the tallest branches in order to feed silk worms because, in so doing, they risk badly spoiling the tree for its next fruit crops.[50] Clearly men had no say, or interest, in silkworm rearing in those times and an open gender conflict was developing in regard to mulberry trees growing on communal lands and maybe also for those growing in home gardens.

Starting in the early fifteenth century, in Italy as well as in France, men gradually replaced women as weavers of higher quality silk stuff and women were eventually banned

[46] Magino 1588, 47.
[47] Broadwin 1999.
[48] A book on the subject and on the role of women in silk making is in its early editing stage: Zanier forthcoming. Two preliminary essays have been published: Zanier 2007; Zanier 2010.
[49] Bonfante 1620, 54.
[50] de' Crescenzi 1605, 239. The Italian epithet translates correctly the Latin one reported in the *incunabulum* of circa 1477. See de Crescentiis 1477.

from joining weavers' guilds or forming their own trade associations. It was part of a wider process of women's marginalisation in economic and social life, which continued for the next few centuries and which can be equally observed in Asia. In some areas of Southern Europe, silk reeling passed, wholly or partially, in the hands of itinerant male reelers. Interestingly, the quality of raw silk reeled by men was on average decidedly inferior to that reeled by women. The core of sericulture stubbornly resisted male encroachment. Silkworm rearing rested firmly in female hands up to the twentieth century, despite repeated attempts to bring it under male control.

2.5 Similarity in Practices and the Role of Technical Innovations

Silk is the only long natural fiber mankind has ever made use of. One cocoon is made up of a single filament whose length in pre-modern cocoons (that is, before Japanese innovations in the early twentieth century) could reach some 600 to 800 meters.[51] Each filament is very thin (0.015 / 0.020 mm.) although its strength equals the strength of an iron thread of the same diameter.

Short fibres (wool, cotton, flax, hemp etc.) have to be intertwined together in a somewhat haphazard way to form a thread. Seen through a magnifying lens a short fibre thread looks "hairy" because of the many loose ends sprouting from it. Its diameter is hardly constant. On the contrary, silk threads are made up of several filaments (up to 80 or more in Medieval times in Europe and in the Middle East) placed with dexterity side by side while going from the basin (where cocoons are immersed in hot water) to the reel and being joined together only by the natural glue (sericin) they are coated with—no twisting whatsoever—notwithstanding what is often maintained in present-day literature. Through a magnifying lens they look like a beam of cohered parallel filaments. Such a thread will reflect far more light than any short fibre thread: hence the extraordinary sheen and brilliance of silk.

At the same time any single minor imperfection (knots, impurities, loose ends), however minute or isolated, will stand out and be immediately perceived by the eye.

The same is true for minuscule variations in its diameter. Tiny imperfections that would never even be noticed by a close inspection of wool or flax thread might easily spoil silk, sharply reducing its selling price. The problem was most acute with plain fabrics, since in operated ones complex design patterns might hide minor imperfections.

It was the duty of a female expert *maestra* to use her skill and concentration to avoid any irregularity in the forming thread. The most difficult part of her job was maintaining uniformity in the diameter of the thread. As the length of filament in each cocoon varied sharply, she had to be aware when one filament of the forming thread was close to end, finger the diameter of the thread and choose the right moment to add a new one picked from a cocoon in the basin.

In medieval times, western silk threads were made of many filaments, 40, 60, even 80 or more, possibly because the diameter of other fibre threads in use were as gross and also because woven fabrics were also rather heavy. Chinese silk threads were much thinner. This is a case of a lowering of the technical content of the Chinese model of silk thread making when it reached the West, in order to adapt to a context of coarser threads, fabrics and garments.

[51] Japanese cross-breeding and subsequent evolution have brought the length up to 2000 metres.

With 40 to 80 filaments in one thread it was relatively easy to keep constant the diameter, as the lack of one or two filaments was hardly discernible. However, when in the late sixteenth and early seventeenth century, Chinese silk cloths and garments began sailing en masse to Europe, textile Europe shuddered in fear. Besides the attraction of their splendid exotic patterns and their much lower cost, those cloths were far lighter, as they were made up of much thinner and more perfectly formed silk threads. Whoever could reproduce these would have a major advantage over competitors. It was then, as a reaction to the renewed challenge of Chinese competition, that silk thread making in selected western areas evolved. As Carlo Poni put it: it was then that "the silk thread [in Italy] became thin and perfectly round."[52] The technical "revolution" took place in Europe only in a few areas, namely Bologna in early seventeenth century, and some fifty years later in Piedmont raising their products (raw and thrown silk) to the top of the market. Silk threads made in the old fashion soon lost their former position. Price differentials between raw silk made by male itinerant reelers in Calabria compared with threads manufactured in Piedmont were in the order of 50 to 100 percent in the late seventeenth century.

Silk reeling machinery was deftly improved with a few ingenious additions—one of which, the crossing of the threads going to the reel, was a novelty in regard to Chinese practice.[53] Machinery and related instruments were standardized throughout Piedmont with repeated sets of detailed written instructions, strictly enforced by frequent inspections.[54] But by far the most important element remained the high dexterity of the *maestre*. They had to be most careful in following the "construction" of the threads meter by meter. It was in Piedmont, probably for the first time ever, that government guidelines prohibited outright the paying of the *maestre* by piece rates. The *maestre* were to be given the time they needed to mind the thread and they had to be paid a daily rate, not by the physical amount of thread they were able to produce. The only variation in pay was based on the quality of raw silk thread produced.

Although the new Piedmont raw silk threads were much thinner than the older threads, their high uniformity and quality meant they were strong enough to be thrown into *organzine*—the special double twisted thread used for warp in high quality silk fabrics—in the giant hydraulic throwing (twisting) plants that within a few decades dotted most of southern Piedmont.[55] In this way Piedmont came to play a basic role in providing, above all, Lyons with a set of high-quality silk threads twisted both for warp as well as for weft. In the course of a short time most of the advanced silk weaving industry in Europe became fully dependent on Piedmontese *organzine*, to the point that they could only produce their best silk cloth if that thread was available. This assured Piedmont of a sort of world monopoly—no comparable threads were available elsewhere—which lasted up to the 1830s, that is to

[52] Poni 1981.

[53] The crossing of the threads was first applied in Bologna in the early seventeenth century and then thoroughly applied in Piedmont. See Zanier 2005.

[54] For details of late seventeenth-century Piedmontese Royal Orders on the subject see Chicco 1995.

[55] The earliest industrial buildings of the sort were built in the 1670s. Nowadays at Caraglio (a small town not far from Cuneo) one of the few remaining late seventeenth-century plants, the imposing "Filatoio Rosso," has been entirely renovated including fully operational replicas of the throwing machinery. A large hydraulic circular silk throwing "tower," operated by a handful of workers, had over 1000 spindles revolving (up to 1800 in the largest plants), that is, substituting an equal number of women operating with hand machinery to twist single threads one by one. Early Piedmontese plants operated four to eight "towers" each. See Mellano and Toselli 2000; Galleani d'Agliano 2013.

say through the early phase of Industrial Revolution, which ironically was largely based on textile technology.

Italian silk throwing technology, employing a highly labor saving ingenious mechanical device, had important characteristics.[56] First, it was not of Chinese origin. Silk throwing machines had been known in China since at least early Song Dynasty (960–1279), but worked on an altogether different principle and design, being much less efficient and producing a thread of inferior quality. Second, the technology first appeared, out of the blue, in Lucca in the late thirteenth century and until now no one has been able to identify any documental trace of where it came from or how, when, and where it was conceived. The only hypothesis, advanced here as a purely speculative exercise, is that its origins may lie somewhere in the Middle East in the early Middle Ages when the response to a vast demand for silk fabrics in the Islamic world and elsewhere forced artisans to devise a machine capable of bypassing the supply bottleneck with a large quantity of adequately twisted threads.[57]

2.6 Conclusion

A whole cycle of an advanced production process migrated from China in the course of several centuries. With it, came beliefs, ritual, and myths. From the start, the silk cycle appears to have been exclusively in the hands of women. Once in the Mediterranean basin it developed on its own, gaining speed in the late Middle Ages to become a significant economic force in several regions around the Mediterranean as well as, mainly for the sole weaving sector, elsewhere in Europe. For a long time it retained close similarities to the original Chinese model, including the gendered nature of breeding tasks. Women initially had exclusive control of it, retrenching in some sectors from the fifteenth century onwards but remaining fully in charge of the most crucial part of it, the silkworm rearing process together with the largest section of raw silk making.

This imprint encompassed several sectors of human activity, behavior and thought. Late into the seventeenth century, when necessity arose, Italian practitioners of silk developed and applied highly rewarding innovations in their attempt to draw near to China's qualitative lead in silks. In the case of raw silk these innovations rendered Piedmontese *organzine* silk the best in the world for well over 150 years. In the early nineteenth century, French producers improved these innovations in silk-reeling and silk-twisting and it was only in the early twentieth century that a full supremacy in silk thread making went back to East Asia, first to Japan, and soon after to China.

[56] Silk throwing mills were largely mechanical and did not request much dexterity on the part of workers who were in the majority men. However, the mills would operate best (in economic terms) only with the use of very high quality raw silk that was produced by expert silk-reelers, women (*maestre*), only.

[57] Details on productivity and a thorough technical analysis of its functioning can be found in Crippa 1990 and Poni 1972.

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