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Essential Processes, Looms, and Technical Aspects of the Production of Silk Textiles

Anna Muthesius

A complex series of moricultural, sericultural, and yarn-producing processes were essential for the Byzantine silk industry. Today in Greece and the Balkans these labor-intensive processes have been radically transformed following the introduction of mechanization and the interbreeding of moths. Before World War II in Greece, raw silk (especially from Souffi) was characterized by a high gum content: small golden-yellow cocoons produced low yields of degummed, golden-yellow raw silk. The equivalent cocoons today are large and white, and they contain little waste gum. This results in a far higher yield of raw silk.¹ Within little more than half a century, raw silk production has been transformed beyond recognition. The same has happened in the Balkans. For this reason, it is generally unsatisfactory to compare contemporary Greek and Balkan practices with those of Byzantine times. Only the nonmechanized silk industries of rural China and India remain unaffected: they act as time capsules that provide living evidence for the intricacies of ancient silk production.²

An unfortunate absence of relevant Byzantine sources concerning the essential processes renders it necessary to turn to non-Byzantine documentation. Chinese sources are particularly relevant, because sericulture was transposed to the Mediterranean from China.³ A key surviving Chinese agricultural treatise, the *Keng tschi tu*⁴ of A.D. 1149

¹ There is no standard bibliography for this topic, but extensive source literature has been gathered in A. Muthesius, *Studies in Byzantine and Islamic Silk Weaving* (London, 1995), studies 7, 11, 16, 17. See also, A. Muthesius, *Byzantine Silk Weaving: A.D. 400 to A.D. 1200*, ed. J. Koder and E. Kislinger (Vienna, 1997), chap. 1. A unique pre-World War II yellow silk cocoon and a hank of yellow (gummed) raw silk was given to the author in 1991 by D. Sakelaridis, the last remaining handwoven silk manufacturer of Souffi.

² For example, see A. Hieromakh, *The Chinese Silk Industry Compiled from Chinese Works* (in Russian) (St. Petersburg, 1865). For a specialized bibliography on contemporary rural Chinese and Indian moriculture, sericulture, and raw silk/silk yarn production, see Muthesius, *Byzantine Silk Weaving*, chap. 1.

³ D. Kuhn, *Textile Technology: Science and Civilisation in China* (Cambridge, 1988), 5.9:421 and 301–2 with bibliography. Y. Tazima, *Silkworm Moths: Evolution of Domesticated Animals* (London, 1984). Cf. M. L. Ryder, “More on Silk in Ancient Egypt,” *Archaeological Textiles Newsletter* 18–19 (1994): 23.

⁴ For the *Keng tschi tu* (also spelled *Keng Chih Thu*), see O. Franke, *Ackerbau und Seidengewinnung in China* (Hamburg, 1913).

provides a detailed account of moricultural, sericultural, and silk yarn-producing techniques.

Moriculture: Planting, Cultivation, Leaf Harvesting, and Pruning

The *Keng tschi tu* indicates that four main activities were essential for successful mulberry growing. In China, mulberries were planted on both flat and terraced land. The first question that arises is how were they grown in Byzantium? There seems to be no documentary evidence regarding this issue. However, if widespread cultivation across mountainous regions of Asia Minor is to be envisaged, the question of terraced mulberry plantations becomes important.

The same Chinese treatise indicates that mulberry seeds planted in spring took about a year to grow into saplings ready for transplanting. The saplings grew to maturity in fifteen years. Byzantine mulberry cultivation in mid-eleventh-century Calabria, as described in the *Reggio Brebion*, the land register of the Byzantine metropolis of Reggio, discussed below, indicates that only mature trees were taxable.⁵

The *Keng tschi tu* emphasized an interrelationship between the nature and size of the mulberry grown and the time and frequency of subsequent leaf harvest. Evidently a continuous supply of fresh mulberry leaves could be ensured only with very careful planning. Timing and rotation of mulberry leaf harvests dictated the number and frequency of silkworm crops reared. It was not simply a matter of a single crop a year.

In Byzantium one knows that in the tenth century there was reliance on foreign imported raw silk, and this, together with the strict regulations against exporting Byzantine raw silk, suggests an overall scarcity of raw silk supplies. In light of the Chinese evidence about multiple crops of silkworms, one wonders why Byzantium could not independently supply its own industry. Was the production of raw silk too restricted and too highly taxed to attract sufficient investment? Alternatively, was local production simply too disrupted because, politically speaking, the plantations were sited in particularly vulnerable regions (first in Syria, later in Asia Minor)?

The *Keng tschi tu* indicates that the mulberry required well-dug soil, preferably irrigated. One may inquire how far the development of irrigation systems might have affected Byzantine mulberry cultivation. Well-irrigated plantations would have been larger, as irrigated trees needed to be more widely spaced. Such plantations would also have significantly increased the volume of raw silk production. Greater production in turn would have meant a larger industry. The growth of sericultural activity in the provinces in the eleventh to twelfth centuries, discussed below, could perhaps best be considered in relation to the development of irrigation systems in Byzantium in general. A. Harvey has indicated that in Byzantium, between the ninth and the eleventh century in particular, considerable interest was shown in the construction of elaborate irrigation systems.⁶

⁵ A. Guillou, *Le Brébion de la métropole byzantine de Reggio* (Vatican City, 1974), 17 and n. 2. Reggio was the capital of the theme of Calabria.

⁶ See A. Harvey, *Economic Expansion in the Byzantine Empire, 900–1200* (Cambridge, 1989), 134–35 and 146, and source references in the accompanying footnotes.

The *Keng tshi tu* clearly shows that in China sericulture was an ancillary occupation of farming communities. The farmers were the silkworm breeders. To what extent was this also true in Byzantium, and to what extent did landed magnates invest in mulberry plantations? One does know that, in the tenth century, wealthy individuals in Constantinople were permitted (within their own homes) to manufacture silks for personal use.⁷

Sericulture

The *Keng tshi tu* indicates that the demands of raising silkworms were even more exacting than those of tending mulberry plantations. Large silk worm crops in mediaeval China were the responsibility of commercial breeders. A Chinese source of the twelfth to thirteenth centuries entitled the *Farmers' Essentials* detailed the precise activities of commercial breeders working in a thirteen bay silk worm rearing house.⁸

At what point did commercial breeders appear in Byzantium? In the sixth century the private silk industry was dependent on state-controlled, imported raw silk supplies. By the tenth century, raw silk was produced in the hinterland, and imported raw silk was commercially available in Constantinople. The rise of Byzantine commercial breeding enterprises in the tenth century can be seen as heralding an increasing decentralization of raw silk supplies in the eleventh to twelfth centuries.

The Byzantine commercial breeders must have adhered to rules like those set out in the *Keng tshi tu* and in other Chinese treatises. These reveal that, after shedding their skins either three or four times according to their breed, silkworms were ready to spin twenty-eight to thirty-five days after hatching. The Chinese silkworms described in the *Farmers' Essentials* were set on suspended trellises and encouraged to spin by warming. The Chinese *Book of Sericulture* of Sun Kuang-Hsien (died 968) revealed how warming also prevented the silkworms from wandering while they were spinning their cocoons.⁹

It is clear from the Chinese documentation that, after spinning, cocoons were either stored in salted jars, stifled by cooling, or speedily unraveled according to need. The question is in what form did Byzantium receive its imported raw silk? The *Book of the Eparch* indicates that both domestic and foreign imported raw silk was reaching Constantinople in the tenth century. Although the transport of salted cocoons from afar would have been a possibility, it would have been more satisfactory for the silk to have arrived in the form of unraveled and reeled silk. Salted silk cocoons would have been brittle and would have yielded poorer silk yarn. Foreign cocoons would also have been bulky to transport over long distances and unprofitable to carry (especially in relation to their raw silk yield and selling price). On the other hand, locally produced cocoons would not have had high transportation costs as they would not have had far

⁷ J. Koder, ed., *Das Eparchenbuch Leons des Weisen* (Vienna, 1991), 104–5.

⁸ For the *Farmers' Essentials* and further sources, see Kuhn, *Textile Technology*, 285–433, and also Bibliography A, 440–53.

⁹ For the *Book of Sericulture*, see Kuhn, *Textile Technology*, 334 and 340.

to travel, and they would not have required salting. They could have been swiftly unraveled by appropriate members of the silk guilds of Constantinople, as discussed below. It is most plausible to suggest that both cocoons and unraveled raw silk were arriving in Constantinople in the tenth century. But it is more likely that local unsalted cocoons would have been traded rather than foreign salted cocoons. The exclusion of brittle, foreign, salted cocoon yarn would have protected the high reputation of the silk industry of Constantinople.

Production of the Silk Yarn

The production of the silk yarn was a laborious and specialized activity. In medieval China, as illustrated in a handscroll datable ca. A.D. 1200–1210, special reeling stoves were evolved (compare those of rural India today).¹⁰ These stoves consisted of a basin above a fire. The cocoons were floated in the basin in a bath of heated water, and their surface was teased to loosen the end of the silk thread of each cocoon. The individual silk starting threads were then fed through separate hooks and led onto a reeling device. Different numbers of cocoons were reeled simultaneously to produce silk yarns of varying weights. The medieval Chinese silk yarns ranged from very fine (the equivalent of see-through silk stockings today) to heavy silk furnishing fabric quality. Surviving Byzantine silks also use very variable weights of silk yarn, which would argue for the early existence of reeling basins in Byzantium.

During reeling, little twist could be added to the threads, and to strengthen silk yarn intended for warps, extra twist (up to 2,000–3,000 turns per meter) had to be added. In China, first the spindle whorl and then, by the tenth to the eleventh century, the spindle wheel were developed for the purpose of adding twist to silk threads.¹¹ In Byzantium, judging by the high twist on warps of surviving silks, there can be no doubt that some form of spindle wheel existed by the tenth to eleventh century.

The Value of a Practical Approach to the Byzantine Sources

All this detailed information is helpful if one wishes to adopt a practical approach to Byzantine sources and avoid mistakes of interpretation. First, it is imperative to acknowledge that the immense complexity of essential processes involved in silkworm breeding (as only briefly outlined above) precludes the possibility that sericulture was introduced “overnight” into the Byzantine Empire in the sixth century, as purported by Prokopios and Theophanes. These authors merely demonstrate the general truth that sericulture penetrated deeper into the empire in the sixth to seventh century. The earliest documented Byzantine silkworms (most plausibly mulberry plantations as well) were located in fifth-century Byzantine Syria.¹²

¹⁰ Kuhn, *Textile Technology*, 60–155, 345–403, esp. fig. 222 on 356.

¹¹ *Ibid.*, 156–236, 404–17.

¹² “From Seed to Samite: Aspects of Byzantine Silk Weaving,” in Muthesius, *Studies*, study 7, 120–22. Cf. M. Kordosis, “The Name Fu-Lin (= Romans),” in *Ἱστορικογεωγραφικά* 4 (1994): 171–78.

Prokopios argued that imperial regulation of silk prices had a ruinous effect on the provincial nonimperial silk industry. R. Lopez interpreted Prokopios' account to mean that the emperor had set a ceiling price of 8 nomismata per pound for the purchase of imported raw silk, but N. Oikonomides took this to refer to silk garments. This low price meant that foreign producers would not sell. If this was true, how did the imperial silk industry survive? Were there imperial mulberry plantations and imperial sericultural establishments to supply the imperial industry? If so, where were these situated? Is it possible that the imperial estates in Syria under the care of Magnos the Syrian, the *kommerkiarios* (silk official), included mulberry plantations? Without further documentary evidence, this is uncertain, but it must remain a possibility.¹³

The *Peri Metaxes* sets a ceiling price of 15 nomismata per pound for raw silk. The problem is to reconcile the 8 nomismata ceiling set for raw silk/woven silk garments described above with the ceiling price stipulated by the *Peri Metaxes*. The difficulty lies in dating the *Peri Metaxes*. Some scholars have suggested that it can be dated before 540, under Justinian, but Oikonomides suggested that the 15 nomismata ceiling price may have acted as only a nominal figure and that it is difficult to date.¹⁴

These ideas need to be balanced from a practical point of view. If raw silk cost a maximum of 15 nomismata per pound at the time of the *Peri Metaxes*, one can envisage that a lightweight shift dress (2 pounds in weight) could be woven for around 30 nomismata. On the other hand, if 8 nomismata was the ceiling for silk garments as against raw silk, the garments in question at a time contemporary to the *Peri Metaxes* would have to have been very lightweight indeed. Only a very flimsy dress could be produced from half a pound of silk. Surviving sixth-to-seventh-century Byzantine silks are all relatively heavyweight textiles: all would have weighed far more than half a pound if made into garments.¹⁵

Concerning the distribution of mulberry plantations and the production of raw silk, the evidence of the seals of the *kommerkiarioi* is important. The earliest seal of a *kommerkiarios* belonged to an officer based in Antioch under Emperor Anastasios (491–518). It is evident that the *kommerkiarioi* originally acted for the state but that subsequently they could draw their own profits. The seals reflect the main thrust of sericultural activity across the Byzantine Empire up to the twelfth century: sericulture evidently passed from Syria to Asia Minor and then into the Balkans.¹⁶ Building on the evidence of the seals, I have suggested that there were five stages of raw silk acquisition up to the twelfth century:¹⁷ (1) an initial phase centered in Syria before the fall to the Arabs (5th–7th centuries); (2) a subsequent stage of sericultural activity within Asia Minor

¹³ "The Byzantine Silk Industry: Lopez and Beyond," in Muthesius, *Studies*, study 16, esp. 258–59 and 276.

¹⁴ "Constantinople and Its Hinterland: Issues of Raw Silk Supply," in Muthesius, *Studies*, study 17, esp. 321–22.

¹⁵ Muthesius, *Byzantine Silk Weaving*, chap. 12, app. A3, cat. nos. M4–M6b; cf. cat. nos. M9–M12, M16, M19–M24.

¹⁶ N. Oikonomides, "Silk Trade and Production in Byzantium," *DOP* 40 (1986): 33–53.

¹⁷ Muthesius, *Studies*, study 17, 315–35.

(8th–9th centuries); (3) a third period of activity concentrated in western Asia Minor and the Balkans (9th–10th centuries); (4) a further initiative that saw the importation of Syrian silks to boost domestic supplies (10th century); (5) finally, a decentralization of raw silk supply (11th–12th centuries). Provincial Byzantine raw silk (Sicilian and Calabrian) appeared on the market at Fustat. Italo-Byzantine, provincial Byzantine silk from Asia Minor as well as imported Islamic raw silks may have been available for use by weavers in the Peloponnese.

The general picture that emerges between the fifth and the twelfth century is one of selective expansion and of increasing decentralization. It is insufficient just to chart these developments. From a practical point of view, these changes in raw silk supply had many ramifications for Byzantine weavers. The quality and nature of silk yarn would have governed both weaving technique and ease of production of designs current at any one time. The slightest change in yarn supply affected both the preparation of the loom and the subsequent execution of the design. Such changes of raw silk supply had to be accommodated by skilled weavers who could envisage how techniques and designs had to be adapted to fresh supplies of yarn.

The fact that five major shifts of yarn production can be discerned, and that domestic supplies also had to be supplemented by imported supplies, indicates that Byzantine weavers must always have been a highly skilled workforce. The specialist divisions of labor as described in the *Book of the Eparch* (discussed below) encouraged the maintenance of high standards.¹⁸

It is difficult to pinpoint the exact location of mulberry plantations before the year 1200. The first Byzantine source that specifically details a substantial mulberry plantation is the *Reggio Brebion*. In the *Reggio Brebion*, mature mulberry trees (i.e., those more than fifteen years old) were subject to imperial taxation at the rate of 2,436 taria (4 taria to the dinar). It is not stipulated whether or not the mulberry leaves were fed to silkworms, although the existence of extensive moricultural and sericultural activity in Calabria in later times would suggest that silk production was involved. The possible size and quality of the Byzantine Calabrian raw silk yield have been much discussed. As demonstrated elsewhere, a practical approach is helpful for an accurate interpretation of this document.¹⁹

Weaving Techniques and Looms

Weaving techniques impose limitations on the types of designs that can be woven on silks. In turn, weaving techniques are dependent on the types of looms used. In Byzantium it was necessary to devise looms with special pattern-producing devices (pattern harnesses) to accommodate increasingly intricate pattern motifs. But sophisticated looms were of no use without skillful weavers. Manual dexterity had to keep pace with

¹⁸ Koder, *Eparchenbuch*, 90–107.

¹⁹ Guillou, *Le Brébion*, 163–201. Guillou's figures were first questioned in A. Muthesius, "Eastern Silks in Western Shrines and Treasuries before 1200 A.D." (Ph.D. diss., Courtauld Institute of Art, University of London, 1982), 254–63. See also Muthesius, *Byzantine Silk Weaving*, chap. 13.

technological development to produce silks of the high quality demonstrated by the surviving Byzantine textiles.²⁰

The main weaving techniques found on the surviving Byzantine silks dating before the thirteenth century are: tabby, damask, twill, lampas, and tapestry weaves. (Satin weave, in which the horizontal thread or weft was permitted to pass over four or more vertical threads or warps before being bound down, was not developed until the 13th to 14th century).²¹ It is useful to define these five weaving types in conjunction with the evidence of surviving examples.

Tabby Weave

In tabby weave the horizontal or weft thread is passed alternatively over one and under one vertical or warp thread (Fig. 1, 1A). All the warps that lie above the weft in the first pass of the thread across the loom lie below it in the next, above it in the third pass, and so on. Tabbies may have either one or two systems of warps and wefts. In tabbies with a second warp, this is hidden between the upper and the lower surface of the weave, and it acts merely to guide the weft to the obverse or the reverse of the fabric.

Some early tabbies with a single warp and weft also employed floats of weft threads for patterning effects. Here the wefts are floated over a tabby to produce simple geometrical designs.²²

Damask Weave

Damask is a weave with a single warp, and the fabric is reversible (Fig. 1, 1D). The threads are bound in twill. There are two faces to twill binding. Where the weft predominates, a weft-faced weave results; but where the warp predominates, a warp-faced twill is formed. The damask contrasts the warp and the weft faces of twill binding.

Twill binding itself, in the case of weft-faced twill, means that the weft is passed over two or three warps and then under one warp, over two or three warps and under one, and so on from one side of the loom to the other. Each successive row begins one warp further in, creating a diagonal furrow down the silk as weaving progresses. The same binding occurs using the warps instead of the wefts in warp-faced twill binding.

Damasks are monochrome weaves that rely on changes in weave rather than on color contrasts for the formation of the pattern.²³

Twill Weave

Twill binding, as described above, is used for this weave (Fig. 1, 1B). There are two warps: a binding warp that secures the weft at required intervals, and a main warp,

²⁰ For standard technical terms, see *Vocabulary of Technical Terms (CIETA)*, ed. D. King (Lyons, 1964). For surviving Byzantine silks, consult Muthesius, *Byzantine Silk Weaving*, app. A1–A4, and chap. 2, introduction to hand draw-loom.

²¹ See King, *Vocabulary*, under names of individual weaves. Another term for tabby is *taffeta*.

²² *Ibid.*, 48.

²³ *Ibid.*, 11.

which sits between the two faces of the weave but does not appear either on the surface or the obverse of the weave. The main warps are lifted or lowered according to the needs of the design, and the action of the main warps determines the correct opening of the sheds for the weaving of the patterns. Main warps are either single or paired in Byzantine silk twills.²⁴ They are of degummed silk twisted to the right (Z).

Central Asian silk twills of the seventh to tenth century used main warps grouped in three to fours and twisted to the right (Z). Later Central Asian twills used paired, gummed silk warps that did not require twisting. They often imitate Byzantine designs but are easily distinguishable from Byzantine twills.²⁵

Byzantine silk manufacture appears to have been largely dominated by twill weaves. Twills were most often polychrome, but in the tenth to eleventh century a fashion also emerged for monochrome twills on which the designs appeared through a change in weave rather than by virtue of color contrasts.

Lampas Weaves

Lampas weaves were developed in both Byzantium and the Islamic Mediterranean around the year 1000 (Fig. 1, 1c). In the Islamic world they were widely woven in Spain and Iran. They are monochrome silks that rely on changes in weave rather than on color contrasts for the formation of their patterns. In early Byzantine lampas weaves, the main warps did not help to bind the wefts, but in developed lampases they did do so.

Two types of developed lampases can be distinguished: tabby, tabby lampas weave and tabby, twill lampas weave. In tabby, tabby lampas weave, the two faces of tabby binding (weft and warp faces) are contrasted to create the design. In tabby, twill lampas weave, tabby and twill bindings are contrasted to delineate patterns (Fig. 1, 1E).

The main warps in lampas weaves are grouped in sets containing combinations of single, paired, or tripled main warps. The groupings of such warps may serve to characterize certain groups of silks (e.g., Spanish lampases as distinguished by D. Shepherd).²⁶

Tapestry Weave

Tapestry weave silks do not survive in large number, but Byzantine examples show the use of the slit tapestry technique (Fig. 1, 1F).²⁷ Here each color area is separated from the next by a slit in the weave. The slits occur where the wefts of one color are turned back upon themselves rather than being carried over into the next color area of the design.

²⁴ Ibid., 52.

²⁵ Muthesius, *Byzantine Silk Weaving*, chap. 10.

²⁶ King, *Vocabulary*, 28. Muthesius, *Byzantine Silk Weaving*, chap. 9, cat. nos. M968, M1044–1045, M1023, M1034, M1035, M951, M1046, M1033, M1024, M1022, and M953, corresponding to the group discussed in D. Shepherd, "The Hispano-Islamic Textiles in the Cooper Union Collection," *Chronicle of the Museum for the Art of Decoration of the Cooper Union* 1. 10 (1943): esp. 365–377. Further relevant references are in Muthesius, *Byzantine Silk Weaving*, chap. 9, n. 33.

²⁷ King, *Vocabulary*, 49.

Medieval Looms

A history of the Byzantine hand draw-loom has not yet been written.²⁸ Surviving pictorial representations of Byzantine looms do not provide any idea of the complexity of the actual looms that must have existed to produce the surviving Byzantine silks. Simple horizontal looms are depicted with shafts but without any form of developed pattern-producing device or “figure harness” that would have been essential for weaving the intricate Byzantine patterns that survive.²⁹ The Byzantine looms must be envisaged with reference to the surviving silks and also in conjunction with documentary evidence for advanced hand draw-loom weaving in Chinese sources.³⁰

J. Becker has suggested that a number of stages can be discerned in what he termed the development of “mechanical patterning” (i.e., in hand draw-loom weaving).³¹ He suggested a move from the use of pattern-weaving devices or pattern heddle rods (sticks inserted into the warps and lifted as required) to true pattern shafts (devices used to create the correct sheds through which the weft was passed). Next he envisaged the development of a form of cross harness whereby strong cords were attached to individual warps across the loom by way of heddle loops. The cords were then knotted to a vertical draw string and suspended above the loom. The draw strings were pulled in the correct order for the opening of the sheds required for the creation of more complex designs. This form of loom is still operational in India today, but it does not seem to have been characteristic of medieval China.

In China there appears to have been a hand draw-loom with a pattern harness placed in a frame behind shafts on the loom. Looms of this type, with two shafts and with a draw harness and individually weighted harness cords, are depicted on a Chinese scroll of the Sung period (960–1277).³² A reconstruction of this type of loom was exhibited in Belgium in 1989, and its construction was based on a nineteenth-century loom from Beijing.³³ The 1989 loom did not have a device for the automatic repeat of the pattern, as did the Beijing loom. Byzantine hand draw-loom after the tenth century probably did include a device for the repeat of patterns, judging by the evenly sized repeats of important extant silks.³⁴

A developed hand draw-loom with pattern-repeating device must be envisaged for Byzantine silks such as the Aachen Elephant fabric of the early eleventh century.³⁵ This

²⁸ J. Becker, *Pattern and Loom* (Copenhagen, 1987), brought together some valuable experimental material prior to his death. See further Muthesius, *Byzantine Silk Weaving*, chap. 2, nn. 1 and 7.

²⁹ For the term *figure harness*, see King, *Vocabulary*, 18.

³⁰ D. Kuhn, *Die Darstellung des Handwebstuhls in China: Eine Untersuchung zum Webstuhl in der chinesischen landwirtschaftlichen Literatur vor dem 19. Jahrhundert* (Cologne, 1975).

³¹ Becker, *Pattern and Loom*, chap. 11, 253–73.

³² *Ibid.*, 262, fig. 244, and 264–65, figs. 246–48. See also, D. De Jonghe, “Métiers à tisser chinois,” in *Chine ciel et terre: 5000 ans d’inventions et de découvertes*, exhib. cat., Musées royaux d’art et d’histoire, Brussels, 16 September 1988–16 January 1989, 273.

³³ *Ibid.*, 185, illustrates modern versions of the 19th-century Beijing type of loom.

³⁴ Muthesius, *Byzantine Silk Weaving*, chaps. 4 and 5.

³⁵ *Ibid.*, chap. 4, and cat. no. M58.

used asymmetrical motifs more than a meter wide enclosed in foliate medallions. Each design required 1,440 manipulations of a pattern-producing device on the loom for the creation of its design. For such a silk to be woven at all, a very sophisticated draw-loom must have existed in the imperial Byzantine workshop at Zeuxippos named in the inscription of the silk.³⁶

Becker suggested that the most advanced hand draw-loom had comber boards, a device for evenly spacing the warps across the loom, but he did not discuss whether this was a device of the Byzantines or a later European development.³⁷ Essentially, Becker distinguished three types of hand draw-loom: an Indian or Persian type with cross harness, a Chinese type with individually weighted draw cords, and a developed European draw-loom with comber board.³⁸ D. de Jonghe divided the looms into essentially two types: those with simple heddle rods and those with necking cords and comber board.³⁹ W. Endrei discerned no fewer than twelve different types of medieval looms.⁴⁰

D. Kuhn distinguished four forms of the Chinese hand draw-loom alone, datable before the thirteenth century.⁴¹ One Chinese source details the exact construction of hand draw-loom, but the account breaks off at the very point of describing the construction of the pattern-producing device, the figure harness.⁴²

Overall one must conclude that it is not possible to see a single line of development throughout. Different workshops would have required different kinds of looms for a variety of weaves. The skill of individual weavers also would have dictated the form and use of a number of looms. Small-scale workshops weaving simple patterns required looms different from large-scale workshops weaving complex and costly pieces. The surviving Byzantine silks give a clue to the stage of development of Byzantine hand draw-loom at different periods between the sixth and the twelfth century.⁴³

Byzantine Looms

Unpatterned or simply ornamented Byzantine silks, including some examples that survive in Sens, could have been woven on looms with relatively simple pattern-producing

³⁶ Ibid., chap. 4, sec. 4.2 and n. 41 for Zeuxippos. Also nn. 37, 39, and 40, for a full discussion of other terms in the Aachen Elephant silk inscription.

³⁷ Becker, *Pattern and Loom*, 253–54, 266, 268, 270, 278, 284, for comber boards.

³⁸ Ibid., 257–70.

³⁹ D. de Jonghe, “Les moyens de façonnage et leurs caractéristiques,” in *Le métier à tisser aux baguettes: Influences orientales dans les costumes polonais et hongrois* (Paris, 1986), 9–16.

⁴⁰ W. Endrei, “L’origine du tissage des grands façonnés,” *L’industrie textile* 4 (1957): 303–7.

⁴¹ See Kuhn, *Textile Technology*. The earliest depiction of a complex hand draw-loom that exists occurs on a Chinese wall painting situated in a hall built between 1073 and 1096. It is illustrated in D. Kuhn, *Die Song-Dynastie (960–1279): Eine neue Gesellschaft im Spiegel ihrer Kultur* (Weinheim, 1987), 386–87.

⁴² D. Kuhn, *Die Webstühle des Tzu-jen i-chich aus der Yüan Zeit* (Wiesbaden, 1977), 66–75.

⁴³ Muthesius, *Byzantine Silk Weaving*, cat. nos. M1–M90, serve as examples.

devices.⁴⁴ However, by the seventh to eighth century, some form of advanced pattern-producing device would have been necessary on Byzantine looms. There may not at first have been devices for automatic repeat of the pattern, as irregularly sized lion-strangler motifs on a Sens silk demonstrate.⁴⁵ But to weave hunter and charioteer themes like those of surviving Byzantine silks at Aachen, sound pattern-producing devices or figure harnesses must have existed.⁴⁶

Unfortunately, no pieces of looms have been excavated in archaeological digs. Brick-lined trenches were discovered in monks' cells at the monastery of Epiphanius in Thebes, but suggestions that these might once have contained horizontal looms with treadles have been dismissed.⁴⁷ Documentary sources are more forthcoming. For instance, St. Theodoret of Cyrillus in Syria, in his treatise *On Providence*, described a working loom:⁴⁸ "Female hands take and spin fine threads. After stretching some threads in order on the looms, they insert the wefts. With the rods they separate the warps, and they loosen some or tighten some attached threads, and the weft thread is then pushed across and beaten down, and so they make the cloth. . . . And . . . who would admire how from the one color of the underlying wool or silk threads, myriad images of various animals and human forms, some hunting and some praying, and pictures of trees and many other things are woven." This passage clearly indicates shed sticks and draw loops in use on Byzantine looms in Syria by the fifth century. It is difficult to reconstruct exactly how the patterning device looked, but it is reasonable to suggest that such a loom could have been developed independently of any Chinese prototype. Chinese silks were predominantly warp faced, whereas Byzantine silks were weft faced. Chinese looms, in any event, would not have been ideally suited to Byzantine weaving techniques.

From the early beginnings of a draw-loom with figure harness system in Syria, more developed systems grew. The most advanced draw-looms may have been built under imperial patronage. The imperial Aachen Elephant silk, of the early eleventh century, demonstrates that such looms were available for the weaving of splendid silks. In modern-day India there are experiments with building hand draw-looms that help indicate the complexity of some of the advanced Byzantine hand draw-looms that existed. For example, one hand draw-loom at a Government Weavers service center in Bangalore in India in the late 1980s was capable of 1,400 steps to produce a pattern repeat.⁴⁹ The Bangalore loom was more than 2 m wide and operated by a total of four weavers. Two weavers were seated at the front of the loom (on either side), and two more weavers sat facing them on a plank supported above the warp. Each of the four weavers controlled the pattern across one-quarter of the width of the loom. Other advanced hand draw-looms in India in the 1980s had pattern-producing devices suspended high

⁴⁴ Ibid., cat. nos. M120a–M322.

⁴⁵ Ibid., cat. no. M44.

⁴⁶ Ibid., cat. nos. M28–M29.

⁴⁷ Muthesius, *Byzantine Silk Weaving*, chap. 2 and n. 26.

⁴⁸ Theodoret of Cyrillus, *De providentia oratio* 4, PG 83:617–20.

⁴⁹ B. B. Dutta and A. N. Dutta, *Multi-tier Jala System on 260 cms. R. S. Handloom* (Bombay, 1987).

above the warps, and up to six draw-boys were sometimes required to operate such devices. Such intricacies should be borne in mind when trying to envisage the Byzantine loom that wove, for example, the Aachen Elephant silk with its 1,440-step pattern repeat.

A number of eighteenth- and nineteenth-century sources depict advanced Chinese draw-loom with the weavers seated in front of the loom and with a draw-boy seated in a wooden structure high above the loom.⁵⁰ Whether the Byzantine hand draw-loom employed this system, or whether the draw cords were led down to the side of the loom to be worked by draw-boys situated on the ground is not documented.

J. Wild and others have demonstrated how early damasks could be woven on relatively simple looms.⁵¹ But a significant development had occurred by around the year 1000 using some form of far more advanced Byzantine hand draw-loom. At that date, Byzantine hand draw-loom (largely built to accommodate the predominant twill weave) had to be adapted to weave lampas weaves. Monochrome lampas weave silks could be produced more cheaply than their polychrome twill counterparts. This was because in lampas the main warps as well as the binding warps were used to bind the patterns, making less labor-intensive lifting of warps necessary to produce identical patterns. Different griffin plus panther design silks were taken from the grave of Pope Clement II (died 1047).⁵² Some of these were woven as twills, others as lampases, and they demonstrate perfectly this transitional stage of development in Byzantine silk weaving. Without doubt, such advances in Byzantine weaving technology were driven by economic concerns.

Byzantine Dyes and Dyeing Techniques

The scientific study of Byzantine dyes is relatively new. To the naked eye, the extant Byzantine silks reveal that a wide color palette was in use by the twelfth century. In particular, the silks indicate that color ranges varied according to period fashions. For instance, a bright polychrome palette of reds, blues, greens, ochers, and off-whites was in vogue in the eighth to ninth century. By the tenth to the eleventh century, side by side with a still comparatively brightly colored mixed palette, monochrome tones were in demand. Single-color golden yellow, purple-blue, olive green, or cherry red Byzantine silks (either incised twills or lampas weaves) datable to the tenth to eleventh century, survive in quantity.⁵³

Early sources show initially how far Byzantine textile dyeing was dominated by concerns to build up and then protect an imperial monopoly over the use of certain murex purple dyes. Such dyes were reserved to treat specially tailored imperial garments. The

⁵⁰ Becker, *Pattern and Loom*, 262–63.

⁵¹ J. Wild, “Tunic No. 4219,” *Riggisberger Berichte* 2 (1994): 9–36.

⁵² Muthesius, *Byzantine Silk Weaving*, chap. 9, cat. nos. M69, M71, M88.

⁵³ Muthesius, *Byzantine Silk Weaving*, chap. 3, with special bibliography. Also see app. A1 cat. nos. M45–M46 (for 8th–9th centuries, polychrome examples) and cat. nos. M77a–b, M86–M88 (for 10th–11th centuries, monochrome examples).

Theodosian and Justinianic codes, and later the *Basilics* and the novels of Leo VI all strongly underline the imperial exclusivity of these murex purple dyes.⁵⁴

G. Steigerwald traced the growth of an imperial monopoly over murex purple from late Roman to early Byzantine times.⁵⁵ He demonstrated that up to the period of Theodosios I (383–395), it was only the purple chlamys that was exclusively reserved for imperial use. Nevertheless, Theodosios I reinforced the edicts of his imperial predecessors Gratian (367–383) and Valentinian II (375–392) and also forbade private manufacture and use of “blatta, oxyblatta, hyacinthina, and their imitations.” Not until the time of Theodosios II (408–450) were specific dress regulations encoded in “De vestibus holoveris et auratis” of the year 424. Steigerwald convincingly argued that the latter did not provide for an imperial monopoly over all murex purples but only over murex-dyed textiles of particular imperial cut. Up to this time members of the Senate as well as private, wealthy Byzantine citizens had worn murex purples. Justinian found it necessary to repromulgate the edict of 424, which suggests that it had met with some opposition in the fifth to sixth century. A Theodosian Code edict of 333 demonstrates the existence of fraudulent dyeing practices in the imperial purple dyeing factory, and it suggests that a black market existed. A further edict of 436, repromulgated under Justinian, drew attention to illegal dyeing in the imperial purple factory of Phoenicia.⁵⁶

Justinian did release imperial half-blatta silks for use by wealthy females in the sixth century, but the practice did not last long.⁵⁷ Leo VI (886–912) allowed citizens to wear clippings of imperial purple, and he castigated his predecessors for earlier denying the populace even this right.⁵⁸ The *Basilics*, on the other hand, forbade illicit manufacture of murex purple on pain of death.⁵⁹ The *Book of the Eparch* of Leo VI (911/912) divided silks into those totally forbidden for nonimperial manufacture and those to be manufactured by the private silk guilds in Constantinople, but only under the supervision of the eparch.⁶⁰ A wide range of variously colored purples were cited among these silks. (Murex is a light-sensitive dye that can range from yellow, green, blue, red-purple, and deep blue purple to near black.) Elsewhere I have discussed in detail some specific terms for such purples, many of which occur in the Baggage Train account of the *Book of Ceremonies*.⁶¹

⁵⁴ Relevant legislation is discussed by P. Pieler in H. Hunger, *Die hochsprachliche profane Literatur der Byzantiner* (Munich, 1978), 2:400–472.

⁵⁵ G. Steigerwald, “Das kaiserliche Purpurprivileg in spätrömischer und frühbyzantinischer Zeit,” *JbAC* 33 (1990): 209–39.

⁵⁶ *CTh* 1.32.1 (A.D. 333), 18.10.20. (A.D. 436).

⁵⁷ *CIC*, *CI* 2.9.3, discussed in Steigerwald, “Kaiserliche Purpurprivileg,” 226.

⁵⁸ P. Noailles and H. Dain, *Les Nouvelles de Léon VI, le Sage* (Paris, 1944), 272ff.

⁵⁹ *Bas.* 19.1.30. See *Basilicorum libri*, 60, ed. H. J. Scheltema, N. van der Wal, and D. Holwerda (Gröningen, 1960), 3:918.

⁶⁰ Koder, *Eparchenbuch*, 96–106 and 90–94, for the wholesale and the retail silk guilds.

⁶¹ See below, “Trade Names,” and Muthesius, *Studies*, study 16, sec. 9. Terms for purples in the Baggage Train account include the following:

- i. ὄξέα (τριβλαττίων καὶ διβλαττίων ὄξέων and ὄξέα διάφορα)
- ii. ψευδοξύς (ψευδοξέα)
- iii. βλαττία

Among the dye analyses on Byzantine silks carried out for the author in the early 1980s, it is interesting to note that one of the imperial Lion silks tested revealed a mixture of indigo and madder as constituents of its purple dye, and not murex dye. The silk appears to be one in a series of diplomatic gifts dispatched to the Latin West in conjunction with marriage negotiations.⁶² It is not unlikely that the Latins would have believed it to be a precious murex-dyed piece. Islamic dyers used a mixture of indigo and a lichen to obtain a similar imitation purple on another silk once mistaken for a Byzantine Lion fabric.⁶³ This appears to be a copy of a Byzantine imperial Lion silk sent as a diplomatic gift to the Islamic world.⁶⁴

Most recently, High Pressure Liquid Chromatography has been used to detect Byzantine dyes. Such tests have highlighted the use of madder and kermes as well as brazilwood dyes.⁶⁵ Murex purple itself occurs on a fine Byzantine griffin silk now at Sitten cathedral.⁶⁶ Murex purple has been detected also (by another process involving vatting, exposure to light, and reoxidation) on a tiny silk scrap taken from the Three Kings Shrine in the Aachen cathedral treasury.⁶⁷

A yellow dye was obtained from weld, and for greens, indigo and weld were mixed. A combination of weld and indigo is found on the Hungarian coronation mantle of Roger of Sicily in Vienna.⁶⁸ The Sicilian workshop that manufactured the silk employed both Islamic and Byzantine silk workers, and it is difficult to be certain whether Byzantine or Islamic craftsmen were the dyers of the piece. Further tests are necessary to establish whether or not the off-white surviving Byzantine silks are dyed. Some may have been totally undyed and only used natural silk yarn, which itself can range in color from off-white to golden yellow.

Guild Organization Related to Technical Aspects

It is impossible to decipher the guild regulations in the *Book of the Eparch* without reference to the actual stages of manufacture of silk yarns and subsequently of silk cloths.

iv. διβλαττία

v. τριβλάττιον

vi. ὀλόβηρος (ὀλόβηρα ιαστὰ)

vii. ιαστός

viii. ἀληθινὰ ἐνθάδια

See J. F. Haldon, *Constantine Porphyrogenitus: Three Treatises on Imperial Military Expeditions* (Vienna, 1990), references for the terms listed above, i–viii, are as follows: i. C243, 244, 251, 259; ii. C244–C245; iii. C300 and discussion on pages 205–7; iv. C173, C213, C235, C236, C240, C242, C251, C258, C504, C508; v. C251, C503, C732, C783; vi. C229; vii. C229, C230; viii. C291, 294, 301.

⁶² Muthesius, *Studies*, study 4, sec. 1, 64.

⁶³ *Ibid.*, 62–63.

⁶⁴ For such gifts, see M. Hamidullah, “Nouveaux documents sur les rapports de l’Europe avec l’Orient du Moyen Age,” *Arabica* 7 (1960): 281–300.

⁶⁵ Muthesius, *Byzantine Silk Weaving*, chap. 3.

⁶⁶ *Ibid.*, cat. nos. M573, M1106, M48, M825–M826, which are dyed with murex purple.

⁶⁷ *Ibid.*, cat. no. M304. Cf. H. Wagner, “The Cologne Fabric of the Three Kings Shrine,” *Bayer Reports* 47 (1982): 24–28.

⁶⁸ Muthesius, *Byzantine Silk Weaving*, cat. no. M100. Also, A. Timár-Balázsky and W. Roelofs, “Identification of Dyes on the Hungarian Coronation Mantle,” *Textile History* 18.1 (1987): 87–96.

Only through a close working knowledge of nonmechanized silk manufacture is it possible to understand the remarkable complexity of the organization of the nonimperial Byzantine silk industry.

The essential processes described in the *Book of the Eparch* relate to the work of the guilds of the Metaxopratai, the Katartarioi, and the Serikarioi.⁶⁹ The guild regulations demonstrate the specialist division of labor not only in raw silk retailing and in silk yarn preparation but also in silk weaving. Elsewhere I have analyzed the duties of the separate guilds in great detail. Here only a summary of important points can be given. Essentially the Metaxopratai, operating in a cartel, purchased but did not work the raw silk. They could only purchase the raw silk in the capital, and they paid tax on the purchase. They had to sell the worked raw silk in approved public markets, and they were not to pass it on illegally. Any cocoon silk would have had to be unraveled and reeled. Then it, as well as already reeled silk, would have required degumming (through boiling), and subsequently the silk would have needed to be wound into hanks. Some of the silk yarn would have been given extra twist in order for it to serve as strong warp thread. The silk from the center of cocoons was waste silk, and this would not have been reelable; instead it would have needed to be spun.

The Katartarioi (and also the Melathrarioi and, in addition, unnamed workers hired by the Metaxopratai) variously worked the raw silk into yarn, but of these only the Katartarioi and the Melathrarioi could purchase raw silk in a cartel with the Metaxopratai. The raw silk that arrived in cocoon form, according to my interpretation of the *Book of the Eparch*, would have been unraveled and reeled by the unnamed workers hired by the Metaxopratai. The Katartarioi were most likely the degummers of filament silk (i.e., those who boiled off the sericin gum from the unraveled and reeled silk). The Melathrarioi, who were poorer guild members, most probably were given the task of spinning the waste silk from the center of cocoons.

Within the workshops, too, there were many distinct skills: loom builders, pattern harness makers, weavers, draw-boys, dyers, and tailors all had to be accommodated. The *Book of the Eparch* described the tenth-century private silk-weaving workshops as a form of communal home to all these distinct, specialized workers. Thus the Serikarioi appear to have been an umbrella guild under which weavers, dyers, and tailors operated.⁷⁰

The Metaxopratai sold a limited weight of raw silk to private Byzantine citizens for manufacture of private clothing in private houses. The Katartarioi received their supplies of raw silk from the Metaxopratai (only as much as they could work), as did the Melathrarioi. The Serikarioi were also dependent on the Metaxopratai for raw silk. The Serikarioi did have the power to hire workers, but it seems unlikely that they bought anything other than unraveled and reeled silk from the Metaxopratai. Any extra workers mentioned in the *Book of the Eparch* were most likely to have been em-

⁶⁹ These guilds have been discussed in great detail in Muthesius, *Studies*, study 16, sec. 7 and 8, pp. 280–90; cf. study 7, pp. 124–25, with chart (pl. 56) that demonstrates the organization of the silk industry and the individual tasks of the different silk guilds.

⁷⁰ Koder, *Eparchenbuch*, chap. 8.

ployed to add extra twist to the yarn. The *Book of the Eparch* fails to reveal to whom the Katartarioi passed on their silk. Perhaps they returned it to the Metaxopratai, or possibly they sold the degummed silk to the Serikarioi. Surviving Byzantine silks all use degummed as opposed to gummed silk yarn.

It has been suggested that the Serikarioi were multiskilled craftsmen crossing all specialties from dressing to weaving, dyeing, and tailoring the silks.⁷¹ This is entirely impractical. Each skill is a lifetime occupation, and different abilities are involved in each task. In addition, some occupations are too dirty to be carried out in the vicinity of weaving itself. For instance, any dyeing operation would have to be kept well away from the weaving, which had to be carried out in immaculate conditions to avoid spoiling valuable cloths. As discussed above, the Serikarioi described in the *Book of the Eparch* must have been some type of factory owners, under whom all these tasks were carried out. In such a factory setting, it was possible for yarn to be plied or twisted, and for the different work of weavers, dyers, and tailors to take place in quite separate workshop spaces.

Trade Names

It is particularly in regulations defining forbidden goods or *kekolymena* that specific trade names for fine Byzantine silks occur. Important sources for these names include the *Book of the Eparch* and the Baggage Train account appended to the *Book of Ceremonies*, and some precious silks also appear in the wills of provincial magnates.⁷² In many cases, trade names have no parallels from which to draw meaning outside the silk trade. On the whole, they can be best interpreted with reference to practical processes involved in their manufacture.

Among the silks expressly forbidden for manufacture and export were the following: (*Book of the Eparch*, 4.1):⁷³ ὀξέων εἶτε καὶ πορφυραερίων μεγαλοζήλων; (*ibid.*, 8.1–2):⁷⁴

⁷¹ D. Simon, "Die Byzantinische Seidenzünften," *BZ* 68 (1975): 23–46, esp. 34.

⁷² Muthesius, *Studies*, study 16, sec. 9, deals in detail with the terms discussed in the section here as well as with some related terms. In that study there is a review of the work on textile terms in Haldon, *Three Treatises*, and of earlier literature, including Koukoules and Reiske as well as of M. F. Hendy, *Studies in the Byzantine Monetary Economy c. 300–1450* (Cambridge, 1985), 304–15. Of the earlier literature, in particular note, see R. Guiland, "Sur quelques termes du Livre des Cérémonies de Constantin VII Porphyrogénète," *REG* 62 (1949): 328–33. For references to the *Book of the Eparch*, see Koder, *Eparchenbuch*, chaps. 4 and 8. For purple silks and precious cloths in the wills of provincial magnates, see P. Lemerle, *Cinq études sur le XIe siècle byzantin* (Paris, 1977): Le Testament d'Eustathios Boilas (April 1059), 15–63, esp. 23–24; La *Diataxis* de Michel Attaliate (March 1077), 67–112; Le *Typikon* de Grégoire Pakourianos (December 1083), 113ff. On the latter typikon more recently, see P. Gautier, "Le typikon du Sébaste Grégoire Pakourianos," *REB* 42 (1984): 5–145, note in particular the list of gifts on pp. 35–44 and gold and the purple imperial garments described on pp. 122–23. In addition, see L. Petit, "Typikon de Grégoire Pacourianos pour le monastère de Pétritzes (Bačkovo) en Bulgarie," *VizVrem* 53 (1904): 24ff, esp. 53 for pearl embroidery and imperial items. Purple silks are described also in an inventory of the monastery of Patmos; C. Astruc, "L'inventaire (1200) du trésor et de la bibliothèque de Patmos," *TM* 8 (1981): 15–30, particularly 21–22.

⁷³ Muthesius, *Studies*, study 16, sec. 9, 291. Koder, *Eparchenbuch*, 90–91.

⁷⁴ Muthesius, *Studies*, study 16, sec. 9, 291–92, and Koder, *Eparchenbuch*, 102–3.

βλαττία κεκωλυμένα . . . ἡμιμηλινοδίβλαττα καὶ πρασινοδίβλαττα μεγαλόζηλα . . . ἰμάτιον, εἶτε ἐξάπωλον εἶτε ὀκτάπωλον, πορφυράερον; (ibid., 8.1–2):⁷⁵ αἵματος for τριβλάττια or διβλάττια. Included in the silks to be declared to the eparch were the following: (*Book of the Eparch*, 8.1):⁷⁶ multicolored κατὰ περσικίων; (ibid., 8.1):⁷⁷ ἰμάτιον . . . δεκάπωλον καὶ δωδεκάπωλον, καὶ τοῦτο ἀληθινάερον καὶ λεπτόζηλον.

Terms applied to types of murex purples occur above as follows:⁷⁸ ὀξέων; πορφυραερίων; ἡμιμηλινοδίβλαττα καὶ πρασινοδίβλαττα. The last two terms refer to peach and to green-purple hues. The διμοίρων ὀξέων have been interpreted to refer to red-purples.⁷⁹ The ἐξάπωλον εἶτε ὀκτάπωλον πορφυράερον are also types of purples.⁸⁰ The most likely explanation for the terms διβλάττια and τριβλάττια are twice and thrice dipped.⁸¹ The term -πωλον is not entirely clear. Elsewhere I have suggested that it pertained to the number of warp threads used, which governed the weight of the silk.⁸² Italian silks of the thirteenth to fourteenth century certainly were regulated in this manner.⁸³ To ensure the correct number of warps, they were accurately threaded in the correct proportions through a reed. If the term did refer to the warps, then it would also suggest the presence of a reed on the Byzantine loom. This is not unlikely, judging by the even spacing of warp threads in extant Byzantine silks by the tenth century.⁸⁴

The term μεγαλόζηλον is difficult to decipher.⁸⁵ Scholars have made various suggestions, regarding it as a reference to size or the value or degree of public demand for the silks.⁸⁶ However, these ideas have little practical use from the point of view of marketing. In fact, λεπτόζηλα (8.2) are distinguished from μεσοζήλων (8.2) and from μεγαλόζήλων (4.1), which points to silks of three densities: fine, medium, and coarse. The term -ζηλον most plausibly indicates the weight of the fabrics. The term is less likely to apply to size of design, particularly as small intricate designs in complex weaves perhaps with brocading, for instance, could easily demand higher prices than those with

⁷⁵ Muthesius, *Studies*, study 16, sec. 9, 291. Koder, *Eparchenbuch*, 104–5.

⁷⁶ Muthesius, *Studies*, study 16, sec. 9, 291–92. Koder, *Eparchenbuch*, 102–3.

⁷⁷ Muthesius, *Studies*, study 16, sec. 9, 291. Koder, *Eparchenbuch*, 104–5.

⁷⁸ Muthesius, *Studies*, study 16, sec. 9, 291, lines 1 and 4 in the list of silks totally forbidden for manufacture. Koder, *Eparchenbuch*, 90–91 and 102–3.

⁷⁹ Muthesius, *Studies*, study 16, sec. 9, line 1 of silks to be declared to the eparch; Koder, *Eparchenbuch*, 92–93.

⁸⁰ Muthesius, *Studies*, study 16, sec. 9, line 5 of silks totally forbidden for manufacture; Koder, *Eparchenbuch*, 102–3.

⁸¹ Muthesius, *Studies*, study 16, sec. 9, line 7 of silks totally forbidden for manufacture. Koder, *Eparchenbuch*, 104–5. Haldon, *Three Treatises*, 205–7, for C173; 221 for C235; 221–222 for C240–241. Hendy, *Studies*, 308.

⁸² Discussed in detail in Muthesius, *Studies*, study 16, at the beginning of sec. 9.

⁸³ D. and M. King, “Silk Weaves of Lucca in 1376,” *Opera Textilia Variorum Temporum: To Honour Agnes Geijer on Her Ninetieth Birthday, 26th October 1988* (Stockholm, 1988), 57–76.

⁸⁴ Muthesius, *Byzantine Silk Weaving*, cat. nos. M48, M53, M55, for example.

⁸⁵ Muthesius, *Studies*, study 16, sec. 9, 293, with comments on Haldon, *Three Treatises*, 218 for C226, and Hendy, *Studies*, 307–8.

⁸⁶ Muthesius, *Studies*, study 16, sec. 9, 295, with comments on Haldon, *Three Treatises*, 217 for C226, where the terms are discussed in relation to size, value, or degree of demand for the silks.

large-scale, simpler, nonbrocaded patterns. In any event, cost was not so much entirely dependent on scale as on whether the designs were symmetrical or asymmetrical. Mirror-image designs, such as hunters in medallions, could be woven using the pattern-making device in a straightforward manner for the first half of the design and then simply in reverse for the mirror-imaged remaining half of the pattern. Asymmetrical designs, on the other hand, required far more manipulation of the pattern-producing device, as there was no reversal of any part of the design entailed. The number of pattern cords required in the case of the symmetrical design was greatly reduced in comparison to that needed for its asymmetrical counterpart. A small-scale asymmetrical design could be far more costly to weave than a larger-scale symmetrical pattern. Predetermined price ranges according to pattern size, in these circumstances, would be very difficult to operate. Some of the terms used in the *Book of the Eparch* are also found in the Baggage Train account appended to the *Book of Ceremonies* (particularly terms associated with precious purples).⁸⁷ Similarly, in the Baggage Train account there are also other common problem terms. For instance, ἰμάτια δεκάλια and ἐξάλια occur in the Baggage Train account,⁸⁸ and they may be related to ἐξάπωλον and ὀκτάπωλον in the *Book of the Eparch*.⁸⁹

Most plausibly, the former terms also designated numbers and weights of warp threads employed, as discussed above in connection with the term -πῶλος.⁹⁰ Other explanations including the value of the silks, degree of gold ornament, and number of loom widths involved in tailoring garments have no technical basis.⁹¹ Silk values depended on too many variables. Gold fabrics could have been, and since earlier times indeed were, described with terms that included the word *gold*.⁹² Surviving silks demonstrate that silks were not woven in narrow loom widths and that very ample looms existed. It would have been unnecessary to tailor using narrow strips. Where silks with selvages have survived, it is possible to detect Byzantine looms up to more than 2 m wide.⁹³

The terms ἀρράφια and ἐρραμένα, it has been suggested, relate to garments with or without sewn panels.⁹⁴ There is no evidence of such silks. It is more plausible to suggest that the terms mean sewn or unsewn and that they distinguish garments woven in the

⁸⁷ Discussed in Muthesius, *Byzantine Silk Weaving*, chap. 3, sec. 3.1, with analysis of G. Steigerwald, "Die antike Purpurfärberei nach dem Bericht Plinius des Älteren in seiner 'Naturalis historia,'" *Traditio* 42 (1986): 1–57, and idem, "Die Purpursorten im Preisedikt Diokletians vom Jahre 301," *ByzF* 15 (1990): 219–76.

⁸⁸ Muthesius, *Studies*, study 16, sec. 9, 294, with comment on Haldon, *Three Treatises*, 229–30 for C289–290, and Hendy, *Studies*, 310.

⁸⁹ Muthesius, *Studies*, study 16, sec. 9, line 5 of silks totally forbidden for manufacture. Koder, *Eparchenbuch*, 104–5. Cf. Haldon, *Three Treatises*, C289–C290, where the same term on the scale of both ten and twelve occurs.

⁹⁰ Muthesius, *Studies*, study 16, sec. 9, 292–93, 295.

⁹¹ Muthesius, *Studies*, study 16, sec. 9, 295, comments on Haldon, *Three Treatises*, 217–19 and C226.

⁹² Consider, for instance, χρυσοῦφάντους λόρους, discussed by I. Reiske, *Commentarii ad Constantinum Porphyrogenitum de Cerimoniis aulae Byzantinae* (Bonn, 1830), 128, A8.

⁹³ For Byzantine loom widths, see Muthesius, *Byzantine Silk Weaving*, chap. 2, n. 24. Some looms were between 2 and 3 m wide.

⁹⁴ Muthesius, *Studies*, study 16, sec. 9, discusses 296; Haldon, *Three Treatises*, 216 and C224.

piece from tailored garments; that is, they served to differentiate “woven to shape” items from tailored garments. The term δίασπρα probably meant two-tone white and referred to silks that relied on weave changes rather than on color contrasts for the formation of their designs (e.g., damasks and lampases).⁹⁵ A number of other terms have been analyzed without reference to technical factors, and the conclusions reached require scrutiny and modification.⁹⁶

Placing Value on the Silks

The *Book of the Eparch* regulated that all silks priced above 10 nomismata were to be declared to the eparch.⁹⁷ The *Russian Primary Chronicle* stated that “when the Russes enter the city, they shall not have the right to buy silk above the value of fifty bezants. Whoever purchases such silks shall exhibit them to the imperial officer, who will stamp and return them.”⁹⁸

The price of individual silks in large part depended on the cost of the raw materials involved. Byzantine raw silk was not traded openly, and it does not appear on price lists together with other raw silks. The average price of standard-quality raw silk traded in the Islamic Mediterranean in the tenth to eleventh century was 2.5 dinars per pound (5.5 dinars per kg). This sum was sufficient to maintain a family for one month.⁹⁹

On certain silks, up to half the cost of production might be accounted for by the use of precious dyes.¹⁰⁰ Purple dyes in particular could add to the costs heavily. From the time of the Edict of Diocletian, a special price range existed for different purples.¹⁰¹ In A.D. 300 the edict indicates that when raw silk cost 12,000 denarii per pound, murex-dyed raw silk fetched an astonishing 150,000 denarii.¹⁰² These prices can best be appreciated through comparison with others cited in the edict. For instance, a haircut cost 2 denarii. A plain silk weaver (and also a sewer cleaner) per day received 25 denarii plus maintenance. Clearly a distinction was made in costs to allow for payment of lesser and more greatly skilled weavers producing simpler and more complex weaves and designs.¹⁰³

Prices for middle Byzantine precious dyes, including murex purple silks, are not

⁹⁵ Muthesius, *Byzantine Silk Weaving*, cat. nos. M10, M11, M85–M87, for instance, for the silks. Explanations for the terms offered by Haldon, *Three Treatises*, are not acceptable on technical grounds and in light of the evidence of the surviving silks.

⁹⁶ For a discussion, see Muthesius, *Studies*, study 16, sec. 9, 296–97.

⁹⁷ *Book of the Eparch*, regulation 8.1. Koder, *Eparchenbuch*, 102–3.

⁹⁸ S. H. Cross and O. Sherbowitz-Wetzor, *The Russian Primary Chronicle* (Cambridge, Mass., 1953), 75.

⁹⁹ S. D. Goitein, *A Mediterranean Society* (London, 1967), 217, 223, and 359, app. B, point 2.

¹⁰⁰ *Ibid.*, 106–8, esp. 107.

¹⁰¹ For the edict, see, in English, T. Frank, *The Edict of Diocletian: An Economic Survey of Ancient Rome*, vol. 5 (London, 1940). More recently, in German, see S. Lauffer, *Diokletians Preisedikt* (Berlin, 1971); discussed in Muthesius, *Studies*, study 16, sec. 10, 301. At a time when raw silk cost 12,000 denarii a pound, murex blatta (best purple) dyed raw silk sold for the extraordinary price of 150,000 denarii a pound. Milesian purple cost 12,000 denarii a pound and bright Tyrian purple fetched 16,000 denarii a pound. Lighter blatta (best purple) sold at 32,000 denarii per pound.

¹⁰² Edict of Diocletian, 23.1.1 and 24.1.1. Muthesius, *Studies*, study 16, sec. 10.

¹⁰³ Edict of Diocletian, 20.1.10 and 20.1.11, for instance.

available, but an incident recorded in the Cairo Geniza documentation suggests that they were still exorbitant.¹⁰⁴ Cambridge University Library document Or 1081 J9 indicates the fate of a Jewish imperial dyeworks employee who inadvertently spoiled an imperial silk. His children were held for ransom while he (after being tortured almost to death) fled to Cairo to seek help from his Jewish coreligionists.¹⁰⁵

The Cairo Geniza documentation of the tenth to eleventh century provides specific details about the value of silks in the dowries of Jewish Mediterranean brides. These bridal trousseau inventories indicate the relatively high value placed upon Byzantine brocaded furnishings in particular. For instance, an undated document records one divan of unknown size, of Rumi brocade, and with two cushions and a back, at 50 dinars. Another document, dated 1156, lists a Rumi brocade divan at 40 dinars. Overall prices varied somewhat. For instance, whereas one Rumi brocade divan without back or cushions in 1140 cost 15 dinars, at the same date, another six-section divan of Rumi brocade was listed at 40 dinars. S. D. Goitein assigned the more expensive example to a rich household and the less expensive one to a lower middle-class household. A bridal diary of the same period (ca. 1140) included “a bed cover of Rumi brocade” at 10 dinars, a “sofa of Rumi brocade (six pieces)” at 40 dinars, and a “sofa of Rumi brocade (3 pieces)” at 15 dinars.¹⁰⁶

¹⁰⁴ Goitein, *Mediterranean Society*, 1:50 in sec. i, 2 and n. 54.

¹⁰⁵ Discussed in Muthesius, *Studies*, study 15, 247. There can be no doubt that the dyer was Jewish and that the document (Cambridge University Library Or. 1081 J9), datable to the 11th to 12th centuries, is important for indicating the presence of Jewish dyers in the imperial workshop. Already in the 10th century an alternative to the Christian oath of allegiance existed for the benefit of non-Christian silk guild members operating in Constantinople. See J. Starr, *The Jews of the Byzantine Empire, 641–1204* (Athens, 1939), 20, 21, 163ff, 221ff.

¹⁰⁶ Goitein, *Mediterranean Society*, 4:299–303 and 322–25.

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