THE SUNSPOT ACTIVITY CYCLE AND THE FORMATION OF THE ANNUAL RING WIDTH IN SOME WOOD SPECIES

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(Received August 1984)

ABSTRACT

The annual ring width of three 85–120-year-old *Quercus cerris* trees, three 105–116-year-old *Betula platyphylla* trees, one 91-year-old *Carpinus betulus* tree, three 172–183-year-old *Larix sibirica* trees, and three 135–208-year-old *Pinus silvestris* trees originating from different sites (Hungary, Mongolia) was compared with cycles of sunspot activity. The effect of sunspot activity on the annual ring formation process of the tree species examined was not unequivocally provable.

Keywords: Sunspot activity, sunspot maximums and minimums, annual ring width.

INTRODUCTION

Solar activity directly affects the upper atmospheric layers of the earth (magnetosphere, ionosphere), but its effect extends indirectly to the whole atmosphere and thus it is observable on the surface of the earth. Solar activity is understood as the cyclic variation of the number of explosions, flares, protuberances, and sunspots occurring on the surface of the sun. The effect of solar activity is taken into serious consideration not only in atmospheric problems (magnetic field variation, aviation safety, radio and TV receiving interferences) but in biological problems (medical-meteorology) as well.

The relationship between the annual ring formation of ligneous plants and sunspot activity has been investigated for a long time all over the world. These investigations extended first of all to the mammoth tree *Sequoia wellingtonia* Seemann. in the United States, and to the Sessile oak *Quercus petraea*/Matt./ Liblein in Europe (Huber-Siebenlist 1969; Libby-Pandolfi 1979). The dendrochronology and dendroclimatology are described in several papers. In addition to the determination of tree age, the authors of these papers discuss the climate, the trend of temperatures, and the quantity of precipitation of past centuries, occasionally searching the interrelation with sunspot activity (e.g. Bauch 1978; Bauch et al. 1967; Fletcher 1978; Horváth 1974; Huber 1935; Majer 1972). However, it is notable that in these studies only secondary effects (temperature variation, quantity of precipitation) of solar activity are taken into consideration. On the other hand, in view of the fact that variation of these factors has been under regular observation only for a relatively short time, conclusions drawn about their effects on the annual ring formation of trees are not acceptable as proof. Papers that deal specifically with the relationship of annual ring width and cyclic sunspot activity are almost nonexistent. The purpose of the present study is to prove the effect of sunspot activity variation (increasing and decreasing corpuscular radiation) on the formation of the annual ring width of several tree species.

Wood and Fiber Science, 18(1), 1986, pp. 76–83

TABLE 1. *Occurrence and other data of the species examined.*

Species, mark of stump, occurrence	Age of the stump, year	Year felled
Quercus cerris var. *austriaca*, Åk/1, Hungary—Komló	85	1974
Quercus cerris var. *cerris*, Åk/2, Hungary—Komló	89	1974
Quercus cerris var. *austriaca*, Åk/3, Hungary—Komló	120	1974
Betula platyphylla, I/2, Mongolia—Tolgojt-Iro	107	1977
Betula platyphylla, I/6, Mongolia—Tolgojt-Iro	105	1977
Betula platyphylla, II/5, Mongolia—Tolgojt-Iro	116	1977
Carpinus betulus, Ma/1, Hungary—Magyarszerdahely	91	1977
Larix sibirica, X/2, Mongolia–Hjalgantszkij	183	1977
Larix sibirica, X/7, Mongolia—Hjalgantszkij	175	1977
Larix sibirica, X/8, Mongolia—Hjalgantszkij	172	1977
Pinus silvestris I/2, Mongolia—Tolgojt—Buguntajszkij	135	1977
Pinus silvestris, II/6, Mongolia—Tolgojt—Buguntajszkij	208	1977
Pinus silvestris, II/7, Mongolia—Togojt—Buguntajszkij	204	1977

MATERIALS AND METHODS

In view of the fact that sunspot activity affects the whole atmosphere of the earth, species of aged frondiferous and Pinaceae species were obtained from localities very distant from each other (Table 1). In the case of tree species, wherever it was possible, efforts were aimed at the examination of at least three specimens of the same age obtained from the same habitat. In the case of the collected specimens—except for the site—no other data were available (e.g. annual amount of precipitation, soil composition, mean temperature, and silviculture data). The Mongolian tree species were obtained from aborigines.

Measurements of the annual ring width were conducted on the cross-sectional discs of the trunks cut at breast-height (1.3 m) in tensile and compressive directions, as well as along the grain, with the aid of a Leitz-type annual ring measuring microscope under 16× magnification.

Dates of sunspot activity between 1975 and 1937 were obtained from a book by L. Detre (Detre 1940), and between 1938 and 1975 from the Observatory of the Hungarian Academy of Sciences (Table 2).

RESULTS AND DISCUSSION

Verification of the possible effects of sunspot activity on annual ring formation was carried out in several steps. The results of the authors' earlier investigations were also taken into consideration (Babos and Filló 1972).

TABLE 2. *Years of the sunspot activity between 1775 and 1975.*

Year of sunspot maxima	Years between two maxima	Year of sunspot minima	Years between two minima
1778.4		1775.5	
	9.7		8.9
1788.1		1784.7	
primer maxima: 1803	17.1		13.6
1805.2		1799.3	
	11.2		12.3
1816.4		1810.6	
	13.5		12.7
1829.9		1823.3	
	7.5		10.2
1837.2		1833.9	
	10.9		10.4
1848.1		1843.5	
	12.0		12.1
1860.1		1856.0	
	10.5		11.2
1870.6		1867.2	
secunder maxima: 1872	13.3		10.7
1883.9		1879.9	
	10.2		10.7
1894.1		1889.6	
primer maxima: 1905	12.3		12.1
1906.4		1901.7	
	10.6		11.9
1917.6		1913.6	
	10.8		9.5
1927.9		1923.1	
	9.8		10.8
1937.7		1933.9	
	10.0		10.3
1947.5		1944.2	
	10.4		10.1
1957.9		1954.3	
secunder maxima: 1959	10.8		10.5
1968.7		1964.8	
			11.3
		1975.8	
Years between two maxima, average:	11.1	Years between two minima, average:	10.5

With regard to aging of the stem-thickening cambium in view of advanced age (Bosshard 1965), the trends of the average annual ring width in the three specimens of the *Larix sibirica* grown in the same habitat at young, intermediate, and old age in the year of sunspot maxima and minima were examined (Table 3, Fig. 1). The conclusion drawn from data of the table and from those of the diagram was that the effect of sunspot activity on annual ring width formation is minimal. Out of the three specimens, in only one case was it definitely evident that the annual rings were affected at sunspot minimums. This fact appeared reversed in the case of the other two specimens.

TABLE 3. *Medium annual ring widths in the samples obtained from the stump of* Larix sibirica *at young, middle, and old age.*

		Stump marked X/2		Stump marked X/7		Stump marked X/8	
Sunspot activity	Year	Annual ring of the stump	Medium annual ring width μm	Annual ring of the stump	Medium annual ring width μm	Annual ring of the stump	Medium annual ring width μm
	1821	27	1,150	9	1,100	17	1,400
	1822		550		1,400		1,900
minima	1823	29	800	11	1,400	19	1,900
	1824		650		1,650		1,750
	1825		650		1,750		1,800
	1826		1,150		2,000		1,500
	1827		1,150		1,550		1,900
	1828		1,950		2,150		1,650
maxima	1829	35	2,200	17	1,500	25	1,700
	1830		1,800		1,850		1,350
	1899	106	350	88	1,600	95	1,150
	1900		500		450		1,450
minima	1901	108	500	90	650	97	1,100
	1902		650		600		1,350
	1903		700		550		500
	1904		600		600		750
	1905		650		650		1,050
	1906		300		450		800
maxima	1907	114	1,400	96	350	103	400
	1908		1,250		350		350
	1909	116	1,700	98	350	105	300
	1962	169	950	161	650	158	800
	1963		1,050		500		800
minima	1964	171	850	163	900	160	800
	1965		1,400		1,050		650
	1966		1,050		650		650
	1967		800		800		750
maxima	1968	175	1,000	167	600	164	700
	1969		1,100		1,400		400
	1970	177	700	169	700	166	550

In the next step, the average annual ring width of each specimen of the five tree species of older trees examined was compared with several sunspot maximums and minimums (Table 4, Fig. 2). On the basis of data in the table and the diagram, it was ascertained that for *Betula platyphylla* and *Carpinus betulus,* the annual ring width was wider only at one sunspot maximum in comparision with the sunspot minimum. In the case of *Quercus cerris* var. *austriaca, Pinus silvestris,* and *Larix sibirica,* the annual ring width was wider in the year of two sunspot maxima than the one formed in the year of two sunspot minima.

Finally, the values of the years of sunspot maxima and minima were taken out of the average values of the annual ring width of the tree species measured annually, and the three values were averaged (Table 5). According to the data of the table, for two specimens out of the three specimens of frondiferous and Pinacea, the annual rings formed in the year of sunspot maxima were found to be wider. In the case of one specimen, the situation was reversed. An exception is the *Carpinus*

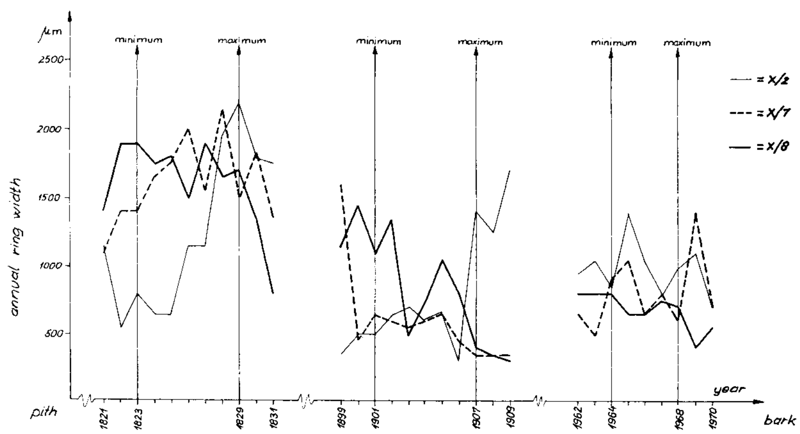

FIG. 1. Medium annual ring widths of three *Larix sibirica* stumps measured at young, middle and old age of the tree, and the sunspot maxima and minima.

betulus among the angiosperms, since it was possible to examine only one specimen, and in this case the annual rings formed in the year of sunspot maxima were found to be wider.

From the diagram (Fig. 3) plotted on the relative number of sunspots (Kálmán 1979), it is apparent that the number of spots increases at a fast rate after the year of sunspot minimum and decreases at a slower rate after the sunspot max-

TABLE 4. *Medium annual ring widths in each sample obtained from five species at the older age.*

		Betula platyph. (marked II/5)		*Carpinus betulus* (marked I)		*Quercus cerris* v. *aust* (marked Ak/3)		*Pinus silvestris* (marked II/6)		*Larix sibir.* (marked X/2)	
Sunspiot activity	Year	Age of annual ring	Medium annual ring width μm	Age of annual ring	Medium annual ring width μm	Age of annual ring	Medium annual ring width μm	Age of annual ring	Medium annual ring width μm	Age of annual ring	Medium annual ring width μm
	1952	92	750	67	1,800	100	400	184	700	148	800
	1953		1,100		1,250		450		550		800
minima	1954	94	700	69	1,850	102	200	186	600	150	900
	1955		850		2,050		400		500		950
	1956		950		2,250		700		600		1,100
maxima	1957	97	650	72	1,200	105	400	189	950	153	1,000
	1958		750		1,700		300		700		1,150
sec. max.	1959	99	700	74	1,800	107	600	191	650	155	850
	1960		1,000		1,550		650		600		1,200
	1961		700		1,450		700		900		850
	1962		750		2,150		700		650		950
	1963		1,100		1,150		650		600		1,050
minima	1964	104	700	79	1,300	112	500	196	700	160	850
	1965		500		850		600		300		1,400
	1966		600		1,100		600		500		1,050
	1967		500		1,500		750		600		800
maxima	1968	108	850	83	1,650	116	600	200	750	164	1,000
	1969		350		2,100		950		500		1,100
	1970	110	750	85	1,150	118	750	202	900	166	700

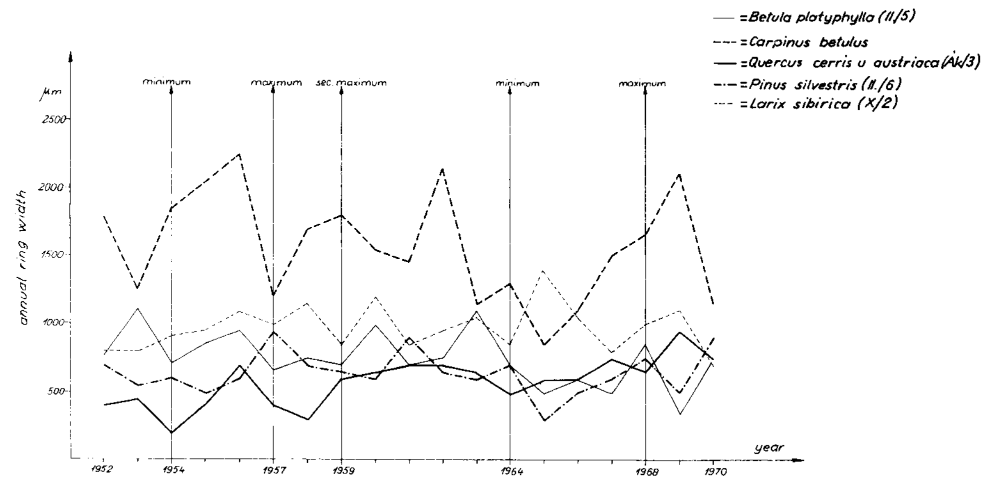

FIG. 2. Medium annual ring widths in each sample obtained from some species at the old age of the tree, and the sunspot minima and maxima.

imum. (The relative number of sunspots, namely the Wolf number, is expressed by the sunspot frequency = number of solitary sunspots + ten times the number of sunspot groups.) It is also a single peak, but primary and secondary maximums occur too (e.g. in the years of 1803–1805, 1870–1872, 1905–1906, 1957–1959) (see also Table 2). Consequently, it can be ascertained that except for a very short period (year of the sunspot minimum, the preceding and following year), our whole earth is bombed by a large number of corpuscular, photon, and magnetic particles during the period of sunspot cycles. Hence in the year of sunspot maxima, the stem-thickening cambium of the trees is exposed to the effect of the most intensive corpuscular radiation. This effect—if it exists—has to be definitely apparent in the annual ring width.

TABLE 5. *Medium annual ring widths of the species during the years of sunspot maxima and minima.*

Species mark of stump	Maxima of sunspot: Number of observations	Maxima of sunspot: Medium annual ring width μm	Minima of sunspot: Number of observations	Minima of sunspot: Medium annual ring width μm
Quercus cerris var. *austriaca*, Ák/1	8	2,081.2	8	1,987.5
Quercus cerris var. *cerris*, Ák/2	8	1,587.5	8	1,825.0
Quercus cerris var. *austriaca*, Ák/3	11	1,313.6	11	1,177.2
Betula platyphylla, I/2	9	950.0	10	930.0
Betula platyphylla, I/6	9	916.6	10	1,060.0
Betula platyphylla, II/5	10	790.0	11	768.1
Carpinus betulus, Ma/1	8	2,325.0	9	2,178.0
Larix sibirica, X/2	16	1,265.6	17	1,070.5
Larix sibirica, X/7	15	899.9	15	1,166.6
Larix sibirica, X/8	16	1,062.4	16	1,002.5
Pinus silvestris, I/2	12	1,100.0	13	976.2
Pinus silvestris, II/6	19	984.2	19	833.5
Pinus silvestris, II/7	17	914.7	19	992.0

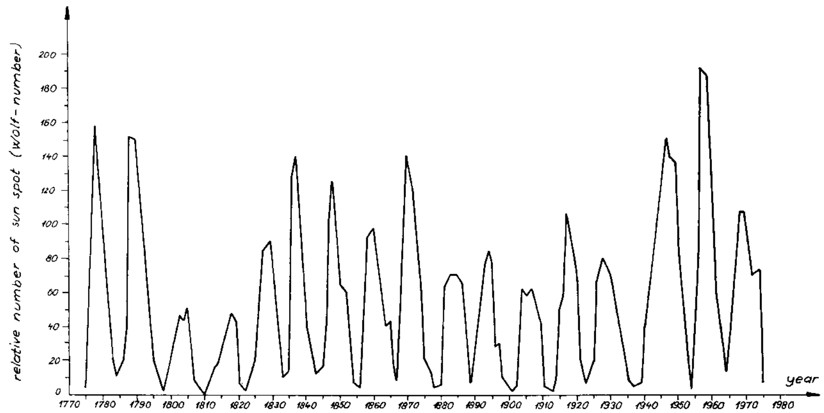

FIG. 3. Sequence of the sunspot relative numbers from 1775 to 1975.

However, on the basis of the results examined, it is evident that no definite connection appeared between the annual ring width and sunspot maxima, even in the case of several tree species. No close connection appeared in the secondary sunspot maxima either (see Fig. 2, Table 4). Examining the trend of the annual ring width of the five species in 1957 (sunspot maximum) and 1959 (secondary sunspot maximum), it is apparent that in the case of three deciduous species, the annual ring width increased, while coniferous species decreased. During the years preceding the sunspot maxima, no increase in the annual ring width was experienced, although because of sunspot activity in those years, the specimens examined were exposed to increased corpuscular and photon radiation.

It can thus be ascertained that the effect of cyclic variation of sunspot activity on the annual ring formation of trees (tree species) is not clearly provable. The stem-thickening cambium of tree species was developed characteristically according to the species during the past millions of years, and thus the cells forming the annual rings are strung out hereditarily according to codes in the DNA and RNA, showing a declining tendency with the age. The number of cells varies annually, and this results in different annual ring formation, which is influenced rather by age of the tree, its position in the stem, and its immediate environment (microclimatic factors), than by variation of the cyclic sunspot activity.

CONCLUSIONS

According to an examination of the results:

The effect of sunspot activity on the annual ring formation of the five tree species examined was not unequivocally provable.

The annual ring was wider in the year of sunspot maximum only in two out of three specimens obtained from the same habitat.

According to an examination of the average annual ring width formed at the young, intermediate, and old age of the three specimens of *Larix sibirica*, the annual rings were wider at only one specimen in the year of sunspot maxima.

Under the influence of more intensive corpuscular radiation appearing at twin sunspot maxima, no wider annual ring was experienced in all the tree species (in three of the five species: the result was positive *Betula, Carpinus, Quercus,* in two species: the result was negative *Pinus, Larix.*

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