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ASTROPHYSICAL INFLUENCES ON SECTORING IN COLONIES OF MICROORGANISMS

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A b s t r a c t

This study was aimed at meta-analyzing by complementary procedures biophysical factors and incidence of colonies with one or more differentiated sectors. Our results showed that astrophysical influences, especially magnetic storms, are prominent in the development of microorganisms.

K e y w o r d s

Astrophysical influences, Magnetic storms, Development of microorganisms, Air bacteria, Staphylococcus aureus

INTRODUCTION

The formation of sectors had been induced by *Witkin (1)* in six populations of *Escherichia coli*, differing in degree of nuclear material multiplicity. Sectoring is complex and can involve changes that are not usually considered under the rubric of mutations. Seemingly spontaneous and mutagen induced sectoring continues to be of interest. The results here presented document that natural physical influences from the remote environment may be involved in modulating genetic microbial change (*2*, *3).* The study was aimed at meta-analyzing by complementary procedures including superposed epochs controlled by blanks, any physical environmental associations with the incidence of colonies with one or more differentiated sectors (CSD) for air bacteria and *Staphylococcus aureus* and further at exploring any geophysical association of changes in microbial sensitivity in the course of routine laboratory tests.

MATERIAL AND METHODS

Experimental microbiological analyses were carried out from 1970 to 1975 in the Hygiene Prophylaxis Laboratory of the Province of Milan and successively from 1976 to 1991 in the

Hygiene Prophylaxis Laboratory of the Province of Rome. *(4,5).* While previous analyses were based on 10-day averages, inferential statistical chrono-metaanalyses of daily data are apparently reported here for the first time.

Between 2 Feb 1970 and 10 Jul 1982, heterogeneous air bacteria were studied and the daily incidence of colonies with differentiated sectors was recorded. Agar tryptose plates had been exposed for 30–60 minutes to the open air, generally between 10:00 and 16:00. Successively, the agar tryptose plates were incubated for two days at 37^{o}C for 24 h. This procedure was carried out each day. Successively, an average of 300–350 colonies were read each day.

Daily values for the geomagnetic disturbance indices K_p and Dst and Wolf number gauging solar activity for the corresponding study spans were obtained from archives on the Internet. Each data series was analyzed by linear-nonlinear least squares rhythmometry *(6,7,8),* in the range of frequencies from 1 cycle per 10.5 years to 1 cycle per year, and from 1 cycle per year to 1 cycle per 2.5 days. Rhythm characteristics at the anticipated periods of 1.0 and 0.5 years were further summarized by population-mean cosinor across all 5 series and also separately across 4 series involving *S aureus* (excluding air bacteria). A population-mean cosinor summary was also obtained at a trial period of 5.25 years corresponding to the second harmonic of the numerical near-match of the solar cycle (used instead of the 10.5-year fundamental component), assessable also on the shorter data series. Another population-mean cosinor summary was prepared at a trial period of 45.5 days, a component found to correspond to a spectral peak in most series. Since this component was not anticipated, we only record its occurrence so that it may be sought in later studies, but we refrain from further comment herein.

Because a stable half-yearly component characterizes both K_p and Dst, and because the data series were not sufficiently long to reliably assess a component with a period of about 10.5 years corresponding to the solar cycle, but were sufficient to assess its second harmonic, a model consisting of these two components was also fitted nonlinearly to each data series.

For the purpose of computing the cross-spectral coherence between each data series and K_p, Dst and Wolf relative sunspot numbers (WN), respectively, the biological data series were linearly interpolated to replace missing values. Least squares spectra indicated good agreement of results between the original data and the interpolated time series. The cross-spectral coherence was computed using the BMDP software with 15, 20 and 30 degrees of freedom to check on the robustness of the findings.

RESULTS

The microbial data as a whole are plotted in the top row of *Fig. 1,* with data on WN as an index of solar activity. Data on K_p and Dst, as indices of geomagnetic activity, are also shown in this figure. On the longest series relating to air bacteria, a component with a period of 9.45 (with a 95% confidence interval (CI of 9.13-9.82) years is validated by non linear least squares. After removal of this major component from the original data series, a circasemiseptan component is found to be statistically significant (P=0.003) and a circaseptan component is of borderline statistical significance (P=0.059) when fitted concomitantly along with the prominent circannual variation (P<0.001). By population-mean cosinor, the circannual and circasemiannual components are statistically significant (P=0.003 and P=0.009), respectively, with acrophases of –299° and –344° (reference: 00:00 on 21 Dec 1969) when the biological series on air bacteria and 4 strains of *staphylococci* are considered. Similar results are obtained when limiting the analyses to 4 populations of *S. aureus*. In the latter case, the 5.25-year component is also statistically significant (P=0.003;

acrophase at –108°C) and the 45.5-day component is of borderline statistical significance (P=0.074).

Table 1 summarizes cross-spectral coherences found away from spectral peaks for bacterial series with K_p, WN and Dst. Any statistically seemingly significant coherences associated with peaks in the spectrum are not listed, to avoid artifacts. Noteworthy are cross-spectral coherences at frequencies of 1 cycle in 3.3 days, 18.6 days and 161.5 days.

Figure 2 shows results obtained by superposed epochs on 28 storms assessed by a K_p larger than 5.625 with respect to CSD, the number of colonies with sectors in 3-day intervals. A lower CSD on the 3 days following the storm, and an increase centered on day 9 following the storm, are suggested by the non-overlap by the vertical 95% CSD confidence intervals of the horizontal midline.

Table 1

Cross-spectral coherence between indices of geomagnetic disturbances, K_p and Dst, or solar activity, WM, with CSD*

Biological data	Environmental Variable	Coherence	(P-value)	Period (days)	(ndf)
Air bacteria	Dst	0.647	(0.005)	18.6	20
		0.471	(0.030)	18.6	30
		0.701	(0.004)	18.6	15
S. aureus K_1 (1)	K_p	0.700	(0.001)	161.5	20
		0.516	(0.013)	161.5	30
		0.748	(0.001)	161.5	15
	Dst	0.515	(0.046)	161.5	20
S. aureus K_2 (1)	K_p	0.701	(0.001)	161.5	20
		0.474	(0.028)	161.5	30
		0.783	(<0.001)	161.5	15
	Dst	0.529	(0.038)	161.5	20
S. aureus K_1 (2)	K_p	0.660	(0.003)	3.3	20
		0.475	(0.028)	3.3	30
		0.694	(0.005)	3.3	15
S. aureus K_2 (2)	WN	0.600	(0.012)	3.0	20
		0.505	(0.016)	3.0	30
		0.654	(0.012)	3.0	15

*K_1-K_3 series had to be split into 2 parts because of a 72-day data gap; (1) corresponds to first part of series preceding the data gap; (2) corresponds to second part after the data gap.

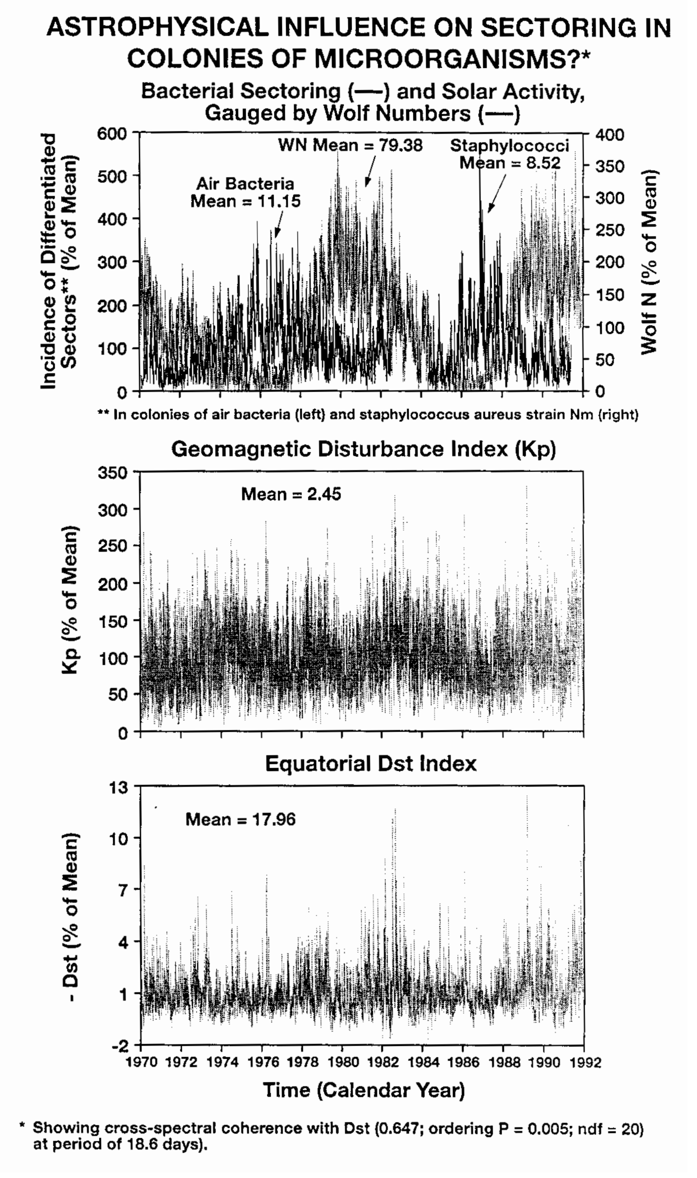

Fig. 1

Microbial sectoring (CSD) data (14–24) are superposed on top upon the data on Wolf's relative sunspot numbers (WN), an about 10-yearly cycle is seen in each variable by the naked eye, as is a phase difference between these circadecennians. Original data on two geomagnetic indices, Kp and Dst, are also shown in the middle and at the bottom of this figure, but the unaided eye has difficulty in discerning patterns.

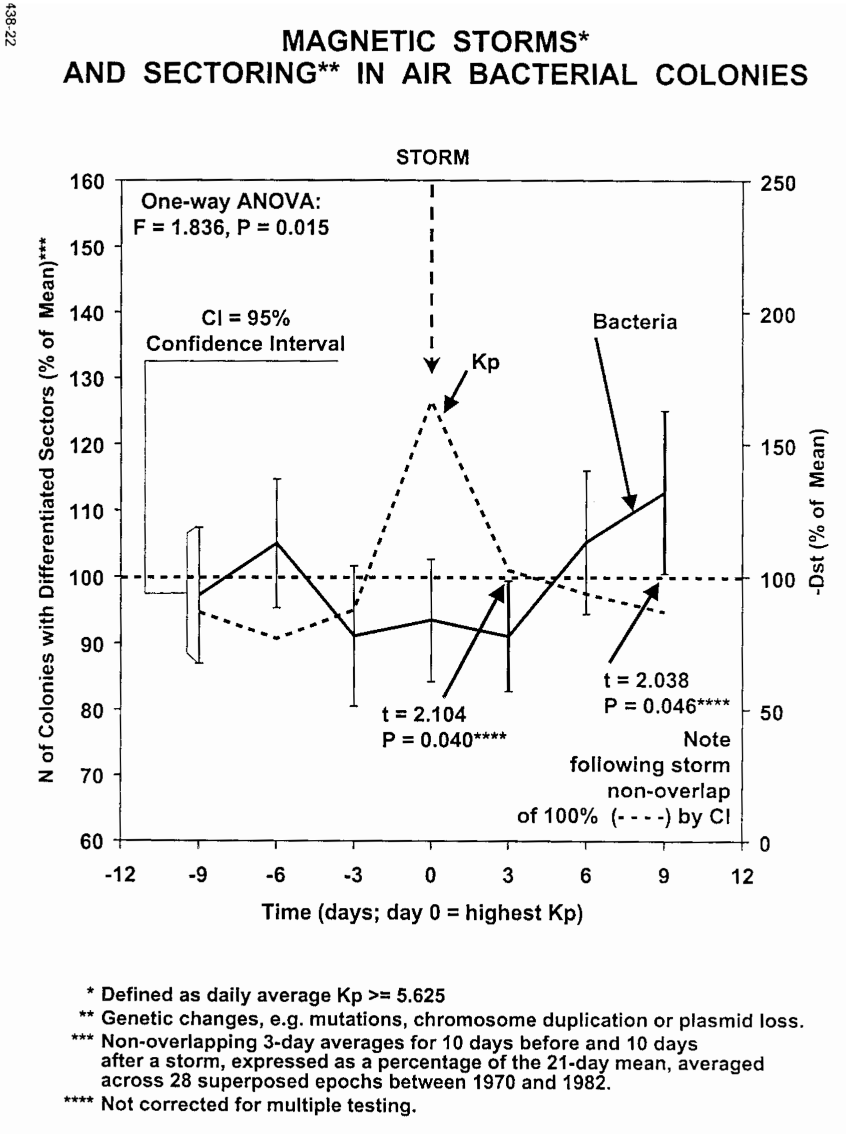

Fig. 2

Summary by superposed epochs of 3-day sectoring data of air bacteria in relation to 28 storms. Each epoch covers a span of 10 days before and 10 days after the day of a storm. The storm is defined by the peak of the highest average of 3-hourly Kp = 5.625 (computed as the sum of 3-hourly measurements totalling = 45 ÷ 8 = 5.625). A decrease of sectoring on day 3 (days 2-4) and an increase in sectoring on day 9 (days 8–10) is seen. The P-value from an analysis of variance (ANOVA) shown on the top left of this figure suggests that a storm has statistically significant effects.

DISCUSSION

The strongest association is found in relation to the geomagnetic disturbance index, K_p, at a frequency of 1 cycle in 161.5 days, in a region close to, albeit away from the prominent half-yearly component characterizing K_p. A statistically significant cross-spectral coherence is found in this region for two populations of *S. aureus*, K1 and K2, and is also found in relation to Dst, even though the association with Dst is weaker. K1 and K2 staphylococcal cultures are also coherent with K_p at another frequency of 1 cycle in 3.3 days. Again, this is a spectral region close to but away from the ubiquitous circasemiseptan component. Earlier studies have suggested that astrophysical influences on biota may be mediated via the circaseptan and/or circasemiseptan components *(8,9,10).*

These components are also in keeping with the sector structure of the interplanetary magnetic field. A remove-and-replace approach has suggested that humans may still resonate with solar circaseptans. These re-analyses by a new approach support the original claim that microorganisms may be influenced by non-photic solar effects upon cosmic rays.

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ASTROFYZIKÁLNÍ VLIVY PŮSOBÍCÍ NA KOLONIE MIKROORGANIZMŮ

S o u h r n

Cílem této studie je metaanalýza biofyzikálních faktorů a kolonií mikroorganismů, které se vyskytují s jedním nebo více diferencovanými sektory, provedená komplementárními postupy. Naše výsledky ukázaly, že astrofyzikální vlivy, zvláště magnetické bouře, se významně uplatňují ve vývoji mikroorganismů.

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