dependent patients relapsed at that time. We speculate that in the first three years, the patients after surgery tried to return to the normal life, but faced several obstacles from the psychological and social factors. When they maintain abstinence for several years, maybe more than three years, they would get accustomed to the new life and would not relapse.

The results of the present study support most of earlier findings related to relapse in drug dependence. The study also emphasizes that two factors which have the most significant influence on relapse in drug dependence are 'relief from disturbance' (psychological factor) and 'peer influence' (social factor). The NAc ablative neurosurgery may promote effective coping strategies for treating drug dependence, and it would be helpful to reduce the relapse rate and focus on the relative time and factors associated with post-operative relapse for patients.

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Schumann resonances observed at Maitri, Antarctica: diurnal variation and its interpretation in terms of global thunderstorm activity

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Schumann resonances (SRs) are the AC components of the global electric circuit and are excited by the lightning activity within the Earth–ionosphere waveguide. An induction magnetometer, which was operated from the Indian Antarctic station, Maitri (70.8°S, 11.7°E), served to examine the SR parameters, namely the amplitude and frequency, in the north-south (H_{NS}) and east-west (H_{EW}) magnetic components. The analysis for the first resonant mode presented in this work reveals a strong UT variation in its amplitude in seasonal as well as yearly timescales. The NS amplitude reveals a semi-diurnal variation with peaks at ~1000 and ~2100 UT, whereas the EW amplitude exhibits a strong diurnal variation with a pronounced peak at 1600 UT. The diurnal curves for the frequency for

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both components are similar in nature to those for the amplitude, but for a time shift. The diurnal trend in the amplitude is retained irrespective of seasons, whereas significant difference are noticed in the frequency behaviour between the summer and winter seasons, especially in the EW component. The observed diurnal variation in the SR intensity is explained in terms of the dominant thunderstorm activity centred over the three convectively active regions: Asia/Maritime Continent (Indonesia), South America and Africa. The diurnal variation in frequency depends not only on the location of the thunderstorm region with respect to the observer, but also on the ionospheric day/night conditions and the Earth–ionosphere cavity thickness.

Keywords: Diurnal variations, global electric circuit, lightning, Schumann resonances.

THE region of space between the Earth and the ionosphere forms a cavity which can support electromagnetic standing waves with wavelengths comparable to planetary dimensions. Schumann resonances (SRs) are the principal components of the natural background electromagnetic spectrum of the Earth–atmosphere system over the frequency range 5–50 Hz. They arise because the global thunderstorm activity at any moment excites the aforesaid cavity and the resulting electromagnetic impulses circumnavigate the globe several times without much attenuation to produce the resonance spectrum. Schumann resonances can be used as a proxy to study the global thunderstorm activity due to their global nature[1], and can be monitored from single stations away from lightning sources[2–4]. Recent observations have demonstrated that SR parameters can provide crucial information about the global lightning activity, global climate and planetary-scale variability of the lower ionosphere[5].

Many researchers have reported that SR intensities undergo diurnal variation at various locations[2,6,7]. Earlier, the diurnal intensity variations have been shown to have a local time dependence with maxima near local noon[2]. It is now recognized that the diurnal and seasonal variations in SR are due to changes in the propagation conditions and the source characteristics. The variation in the propagation conditions for electromagnetic waves arising from lightning is expected to be due to the day–night differences in ionospheric morphology. The location of the observing site with respect to major lightning centres would also contribute to the diurnal variation in the intensity of the Schumann resonances.

The present communication describes the diurnal and seasonal variations in the magnetic components of the first resonant mode of SR observed over a period of one year at Maitri, one of the two Indian stations presently operating in Antarctica from the icy continent. The results are examined in the context of our current understanding of the temporal behaviour of the SR parameters.

Though there are several studies on SR parameters based on measurements made over several mid- and high-latitude sites, measurements from the Antarctic have been sparse. As Maitri is far away from any lightning activity, useful studies on global lightning activity can be carried out with the measurements of SR parameters from this site. Moreover, as demonstrated in an earlier work[5], long-term records of SR intensities would serve to monitor trends in the global surface temperature. While undertaking an exercise of such a kind, it is important that we understand their diurnal and seasonal variations and are able to relate them to the corresponding variations in the source regions and the geometry between the source and observer as well as to the variations occurring in the ionospheric height and cavity thickness. The present study is an effort in this direction.

Measurements made by the three-component induction coil magnetometers (ICMs) (make: LEMI-30i of Lviv Center of Institute for Space Research, Ukraine) deployed at Maitri, were utilized for the present study. The magnetometer units comprise of three induction coils and a communication and measuring (CAM) unit. Two of the coils were installed along geomagnetic north-south and east-west directions to yield the respective magnetic field components (H_{NS} and H_{EW} respectively) and the third was aligned in the vertical. The magnetometers captured the desired magnetic field signals in the frequency range 0.01–30 Hz. Data gathered by the CAM unit are transmitted for storage to an external PC.

For our analysis purpose in the present work, we have considered only the NS and EW magnetic components for the year 2011. Data were recorded at a sampling rate of 64 Hz. The raw time-series data were stored and the SR parameters were obtained during the post-processing of the raw data. The raw data were corrected to the geographic coordinates using the transformation equations. We could gather 132 days of useful observations for this year after eliminating days with noisy data or when the experiment was not conducted. For the present study, we have used the frequency range from 5 to 30 Hz, which includes the first three SR modes recognized at Maitri. To calculate the amplitude and peak frequency, the spectra were fitted with Lorentzian curves as has been done in the past[8], yielding the frequency, resonance quality factor and peak power spectral density for each mode. Results pertaining to the SR parameters (power/amplitude and frequency) computed for the first resonant mode between 7 and 9 Hz for both NS and EW components are presented and discussed in this work.

The 30-min individual spectra for all days were averaged over the whole year. Figure 1 depicts the results from this exercise. The amplitudes are expressed in $pT/Hz^{1/2}$. As expected, the first three modes at 8, 14 and 20 Hz can be prominently seen and the instrument captures them well. A similar instrument has been used by earlier workers from the low-latitude station, Agra, in the Indian sector[9].

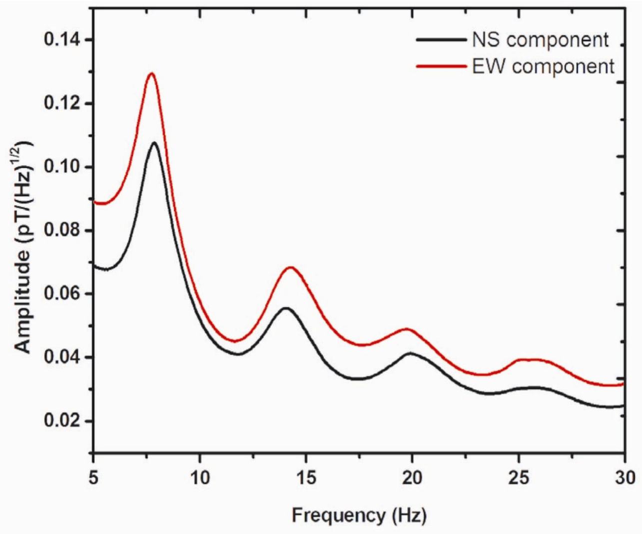

Figure 1. Annually averaged amplitude spectra of Schumann resonance over Maitri, Antarctica.

A prominent feature of the observations reported here is the strong diurnal variation of the intensities of the SR modes. This was anticipated as the rotation of the Earth changes the location of the observer with respect to major afternoon thunderstorm centres and the propagation conditions for the electromagnetic waves would also vary when part of the ionosphere would lie on the dayside and the rest on the nightside. In Figure 2 we depict the temporal variation (in UT hours) of the amplitude and frequency of the first mode in the annually averaged sense. Wherever error bars are shown, they represent the standard deviation for the corresponding data point averaged over the selected period. We immediately notice that the diurnal curves of the amplitudes for the two components reveal a systematic variation. The amplitude of the NS component displays a semi-diurnal pattern having peaks, one around 1000 UT and the other around 2100 UT. The EW component shows a small peak around 0700 UT and a single larger peak, stronger than the NS component, at around 1600 UT.

From Figure 2 (left panel), we infer that the diurnal variation of the NS magnetic component, which shows two maxima, is possibly associated with the thunderstorm activity over Asia and South America (the time of occurrence in both maxima correspond to late afternoon local time over these continents with respect to the observing station; for example, peaks between 0600 and 0800 UT would correspond to the deep convective activity over the western Pacific region; peaks around 1000 UT would correspond to the activity over the Indian sector, and peaks around 2100 UT could be related to the thunderstorm activity over the American region). As the magnetic perturbation vector is aligned perpendicular to the propagation wave vector, we anticipate the sensors would pick up those waves whose propagation vector is orthogonal to the alignment of the sensor. For the NS component, we expect the waves to arrive at a substantial angle to the observer at Maitri, which implies that their sources would be possibly located in the thunderstorm regions far away towards northeast over the Asian sector for the 1000 UT peak and towards northwest over South America for the 2100 UT peak. It may be noted that the continental regions in the tropics over these locations would support deep convection during the corresponding local afternoon hours. In the EW magnetic component (H_{EW}), a strong maximum around 1600 UT suggests that it is related to the peak thunderstorm activity in Africa (north of Maitri).

Figure 2 (right panel) shows the diurnal frequency variation in the first mode of SR for the whole year. Two prominent peaks are visible in the NS and one in the EW components. The reasons for this diurnal frequency variation are not known yet, but we expect contributions to these variations to arise not only from the source–observer geometry but also from the ionospheric height movements and conductivity variations.

Figure 3 (left panel) shows the diurnal variation of the amplitude of the first SR mode in the NS component during the southern hemisphere summer (November, December, January and February; NDJM), winter (May, June, July and August; MJJA) and equinox (March, April, September, October; MASO) during 2011. Larger error bars shown for the equinox months are due to the fact that the results for the two equinox seasons have been combined and also that there were few days available in the month of March. Two peaks are observed in the NS component of SR, one between 0800 and 1000 UT and the other at around 2000 UT for all three seasons, which were earlier ascribed to the thunderstorm activity occurring over the Asian/Maritime Continent and the South American continent respectively. Figure 3 (right panel) shows the diurnal variation of SR in the EW component. Here, we notice a strong peak at 1600 UT for all three seasons with similar amplitudes along with a secondary peak between 0600 and 0800 UT. Earlier, the results for the annual average for this component indicated potential sources to lie in Africa.

Tables 1 and 2 provide the results for the amplitudes and phases of the diurnal and semi-diurnal variations of the SR parameters estimated in the least squares sense. With regard to the intensity of the SR mode (Table 1 and Figure 2), one can notice a stronger and dominant diurnal signature in the EW component and a stronger semi-diurnal signature in the NS component. Moreover, the diurnal amplitudes in the EW component are double the amplitudes in the NS component.

In general the diurnal variation of SR power or amplitude has a tendency to respond to the thunderstorm activity occurring in the three tropical chimneys, namely, Asia, in particular, over the Indo-Tibetan land masses as well as the Maritime Continent (Indonesia), Africa and America. The influence of the thunderstorm activity over the Asian

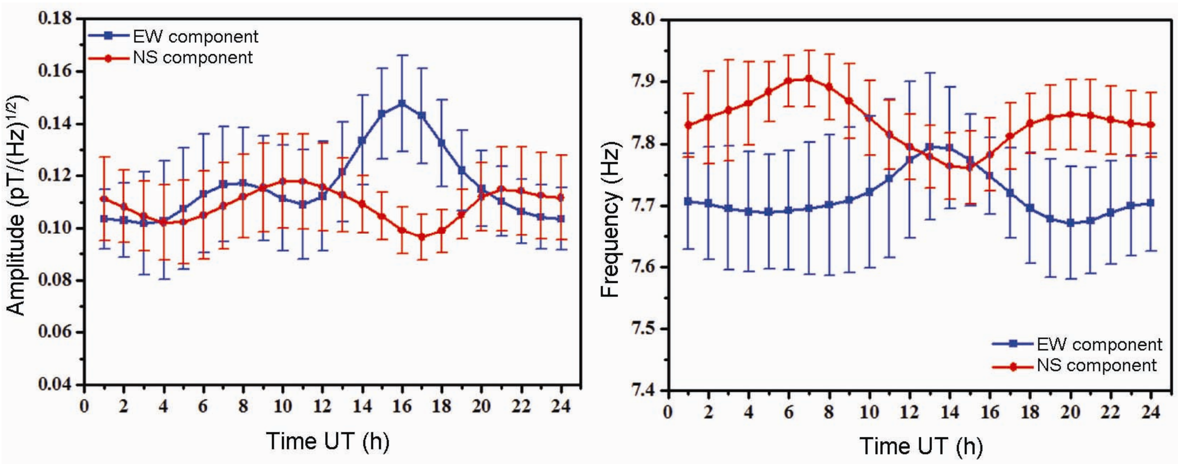

Figure 2. Annually averaged amplitude (left panel) and frequency (right panel) variation of the first SR mode at Maitri.

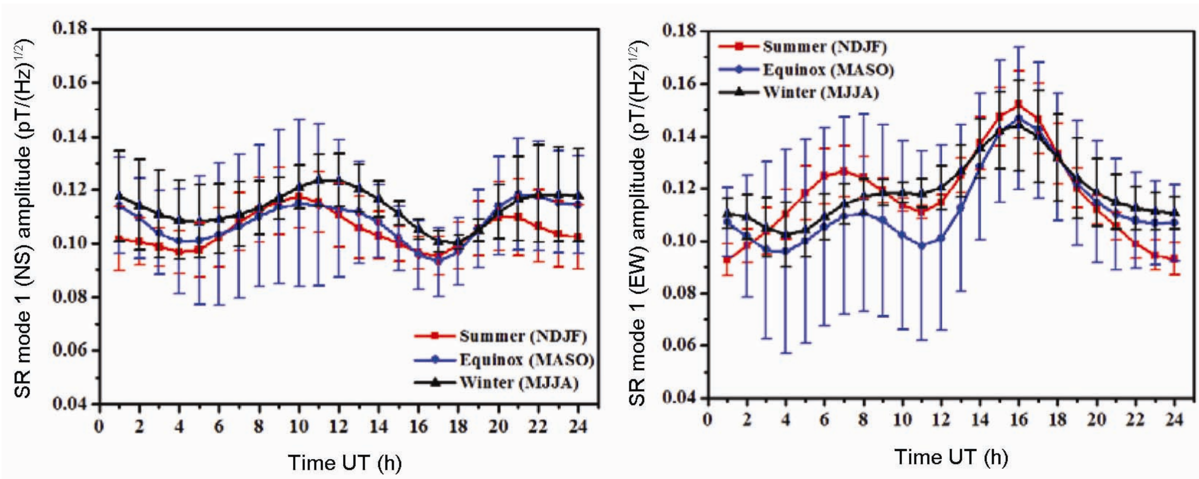

Figure 3. Mean diurnal–seasonal amplitude variation of the first SR mode in NS (left panel) and EW (right panel) magnetic components at Maitri.

sector has been shown to be important for the behaviour of Schumann resonance intensities over Kolkata, a tropical station in the Indian sector[10]. In experiments carried out over Negev Desert, Israel, three dominant maxima (0800, 1400 and 2000 UT) were observed in the diurnal variation of SR power[11]. These maxima were attributed to the thunderstorm-active regions over Asia (0800 UT), Africa (1400 UT) and South America (2000 UT). It may be noted that this site is away from the three major thunderstorm active regions (Asia, Africa and America), zonally all separated from each other by 90°. Whereas, for Maitri, major thunderstorms are quite far away from the source regions and the arrival angle for the ELF waves will be ~45° for the Asian and American thunderstorm regions and 90° for the African thunderstorm region. Therefore, the variation in the amplitude between these stations (Negev Desert and Maitri) will have some similarities for the NS component corresponding to the thunderstorm activity of Asian and American sectors at 0800 and 2000 UT respectively. We expect similarities in the EW component as well when the respective sensor oriented in that direction responds to the thunderstorm region located in the African sector.

Amplitude monitoring from widely separated stations has also been carried out in the past[3,12,13]. Results from these experiments support the idea that the global thunderstorm activity is concentrated over the continents in the tropical zone and its current peak is located in the zone closest to the dusk terminator (local afternoon hours). Thus, the source–observer distance reaches its minimum near the local time corresponding to the late afternoon hours[14]. From the SR observations made at Barentzburg (78°06′N; 14°12′E) in Russia, nearly a conjugate station for Maitri, it was noticed that the SR intensity has a double peak in H_{NS}, one at about 0800 UT and the other at about 2000 UT[13]. However, the east-west component, H_{EW}, shows a prominent single peak at ~1400 UT and a secondary peak at ~0600 UT. The features observed

Table 1. Diurnal and semi-diurnal amplitudes and phases of the Schumann resonance (SR) parameters of the first mode (phases given in brackets)

SR parameter	Season	NS diurnal	EW diurnal	NS semi-diurnal	EW semi-diurnal
Amplitude (× 10^{-3} pT/(Hz)$^{1/2}$)	Summer	3.85 (10.3)	17.8 (13.7)	7.74 (9.7)	14.5 (5.1)
	Equinox	1.97 (2.3)	16.2 (16.6)	9.34 (10.6)	9.0 (4.8)
	Winter	2.66 (8.2)	15.1 (15.4)	8.41 (11.4)	4.16 (4.1)

Table 2. Same as in Table 1, but for frequency of the first mode

SR parameter	Season	NS diurnal	EW diurnal	NS semi-diurnal	EW semi-diurnal
Frequency (× 10^{-2} Hz)	Summer	4.07 (5.0)	1.89 (14.1)	4.27 (7.4)	3.74 (2.1)
	Equinox	3.34 (3.5)	4.92 (13.7)	3.28 (6.9)	3.0 (1.5)
	Winter	5.28 (3.8)	4.95 (11.7)	3.44 (7.9)	3.3 (0.7)

at Maitri are nearly similar to the observations made from the northern hemisphere conjugate station. From the above, one may conclude that the observed diurnal variations in SR amplitude over Maitri are due to the thunderstorm activity occurring on a global scale over the three regions located in the Asian/Maritime Continent and the American and African sectors.

The resonance frequency for mode 1 undergoes a systematic and consistent diurnal pattern during different seasons. Figure 4 shows the diurnal pattern of frequency variation for both magnetic components. In spite of the large scatter, we notice two peaks, especially during the equinox seasons, near 0600 and 2000 UT in the NS component and a single peak near 1300 UT in the EW component, a clear semi-diurnal variation of the frequency in the NS component and a diurnal-type variation in the EW component similar to the variations observed in the mode amplitude (Figure 3). The maximum occurrence time of one of the components is almost coincident with the minimum occurrence time of the other. For example, the occurrence of the minimum at 1400 UT in the NS component coincides with that of maximum in the EW component. Another feature to be noted is that there are greater seasonal changes of mean frequency in the EW component than those in the NS component. The diurnal mean frequencies for the EW component are larger during winter and comparatively smaller during summer. It may be noted that the results for the mean frequency over Negev Desert reveal greater seasonal change in the NS component, with the time of occurrence of maximum varying with time and season. Further, results presented in Tables 1 and 2 for Maitri reveal that the frequency variation leads the amplitude variation by 2–4 h.

The diurnal variation of the resonance frequency was earlier hypothesized to be caused by the motion of the thunderstorm active centres around the globe[15,16]. Later, it was speculated that the diurnal variation was due to the combined effect of day–night asymmetry and the eccentricity of the geomagnetic field, since the ionospheric parameters are different for the day and night sides of the globe[17]. The magnetic dipole component is stronger on one side of the globe than on the other side. Further, the dipole is closer to the centre of the night hemisphere during noon (UT), where the effective height of the ionosphere is greater and later as the dipole moves towards the day hemisphere, the ionosphere gets lower. Thus, the periodic modulation of the thickness of the Earth–ionosphere cavity was suggested to drive the frequency variation of the global resonance.

The mode frequency was shown to depend not only on the zenith angle of the Sun along the signal propagation path from a lightning source to an observer point, but also on the planetary magnetic disturbances[17]. Some authors attribute the variation in frequency on any day to the solar proton events[18,19]. Measurements in the Himalayan region indicate that the resonance frequency is determined by the effective size of the thunderstorms and associated ionospheric conductivity[20]. Results from Agra, demonstrated a variation in the mode frequency with solar cycle that is believed to occur essentially through conductivity changes and subsequent ionospheric height changes[9].

It was also suggested that the shifts in the frequency are due to leakage of power in the dissipative medium. The latter is primarily dependent on the distance to the excitation source, as late afternoon thunderstorm regions vary with time for an observer fixed to the Earth. This is an artifact of the source–observer geometry and is not related to the properties of the Earth–ionsophere cavity[21].

All these investigations clearly reveal that the diurnal variation in frequency can be significantly altered by the ionospheric parameters in the propagation path of the signal as well as the distance between the source and the observer. Since the source of resonance is the thunderstorm activity over the respective three tropical chimneys separated by 90° longitude, i.e. between Africa and Asia, and Africa and America, the peak of the resonance frequency variation is expected to have a complicated diurnal pattern owing to these conditions.

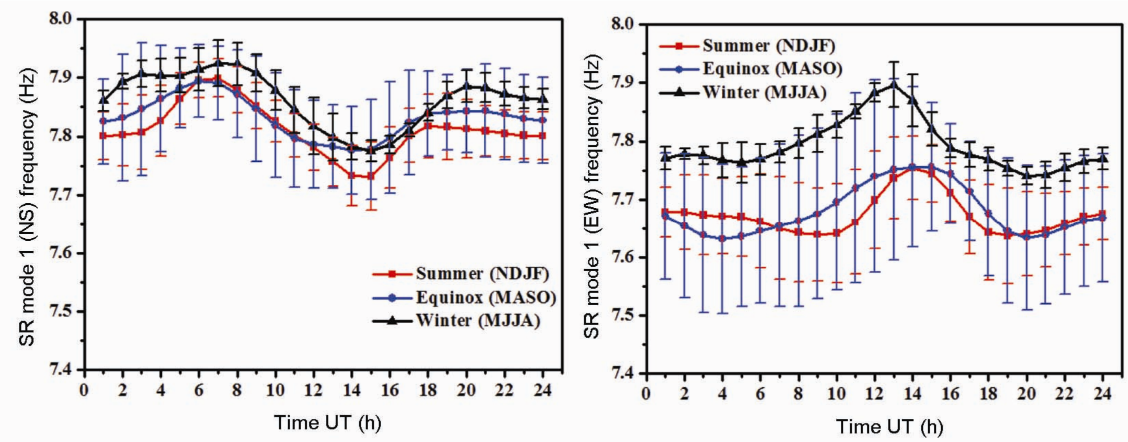

Figure 4. Mean diurnal–seasonal frequency variation of the first SR mode in NS (left panel) and EW (right panel) magnetic components at Maitri.

Returning to the discussion pertaining to the present observations, the steady rise in the diurnal frequency of the H_{EW} component in Figure 4 (right panel) suggests that the thunderstorm activity in the tropical Asian and African regions resonates the cavity with the frequency rise attributed to the increase in the energy of the cavity. At about 1200 UT, it attains its maximum and thereafter a steady fall is seen despite the continuation of energy in the cavity. This is probably due to the rise in conductivity in the propagation path between the source and the observer. The decreasing trend continues till 1800 UT, with the lowest value occurring around this time. Thereafter, it rises as the conductivity decreases. It is to be remembered here that though the H_{EW} component is dominated by the African thunderstorm activity, it is also influenced by the other two tropical chimneys located in Asia and America, as the angle between the source and observer is more than 0°. A reverse of the above pattern is seen in the H_{NS} component, which can be understood based on the reasoning provided above but taking into account the other two thunderstorm generators.

From the SR observations carried out at Maitri, it is evident that it is the lightning flash density along with an alignment of the resonance cavity with respect to the sensor that determines the strength of the detected power or amplitude. Here we have studied the characteristics of the AC component of the global electric circuit, namely the amplitude and frequency of the SR parameters. It has been shown that the NS and EW induction coils reveal maximum intensity of signal when the signal propagation path is 90° to the direction of orientation of the sensor and nearly half the intensity when the signal propagation direction is inclined to about 45°. The geographical location of Maitri, in Antarctica, is just south of Africa. The signal propagation path from Africa to Maitri is nearly 90° and the maximum intensity at 1600 UT revealed by the observations made by the EW sensor could very well be in response to a source in the African continent. The H_{NS} sensor reveals two maxima, one at around 1000 UT and the other at 2100 UT. The amplitude of SR (H_{NS}) is nearly half that of the signal detected by the EW sensor as the source of the thunderstorm activity (MC and American sector) is nearly at 45° bearing. Considering the signal strength and occurrence of these maxima, it is evident that these features are consequences of the thunderstorm activity over the Asian and American sectors. In accordance with the earlier reports, we conclude that the variation of the resonance frequency in mode 1 is related to the variation in the intensity of the thunderstorm activity as well as the behaviour of the Earth–ionosphere cavity.

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Correlation patterns among floral traits in *Cleome viscosa* L., a sexually polymorphic species

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***Cleome viscosa* L., a multipurpose species, is reproductively versatile exhibiting variation in the sex of its flowers. Being predominantly andromonoecious, few plants occasionally exhibit functional monoecy. Andromonoecy is distinguished by the production of hermaphrodite and staminate flowers, while formation of pistillate, male and other intermediate flower types leads to functional monoecy. Size variation in these sexes is equally prevalent. Size dimorphy in all the flower types leads to significant differences in almost all the morphological features. Overall 12 different flower types thus distinguished were analysed for different morphological traits. The data generated were subjected to correlation analyses to determine the extent of relationship between them, and thereupon reflect on the mechanism of their selection in flowers of different sexes and sizes. Despite male fitness traits being at greater advantage in all flower types, female fitness is equally selected in hermaphrodites and exclusively in pistillate flowers. Others with staminodes show mixed fitness. A critical analysis of the morphological data and their correlations suggests that different pairs of traits in each flower type are evolved in ways unique to them and to maximize their functional potential. Natural selection is thus operating through differential correlation patterning and is probably driving the evolution of these flower types.**

Keywords: *Cleome viscosa*, correlation patterns, floral traits, hermaphrodite.

FLOWER is a specialized shoot apex in which different organs are functionally tailored to facilitate reproduction[1,2]. Structural and functional aspects of sex organs (male and female) and accessory (flower display unit) parts within a flower have mutually evolved and are strongly correlated to increase pollination efficiency which ultimately affects the reproductive potential of plants[1,2]. The correlation analyses on qualitative and quantitative floral traits carried out by various authors from time to time reveal that these are under continuous evolution and are stabilized by natural selection according to the needs of a plant. For example, pollinator-driven traits like corolla size, stamen length, pollen presentation and floral rewards are strongly correlated in xenogamous taxa where these traits facilitate out crossing. On the contrary, male and female traits are highly correlated structurally and functionally in selfers[3–9].

Interrelationships between various traits have been studied extensively in flowers of different sexes. In *Commelina communis*, an andromonoecious plant, the hermaphrodite flowers exhibit stronger stigma–anther correlation, while staminate ones show greater anther–petal correlation. Selection in hermaphrodites thus, favours successful pollen deposition and fertilization followed by seed set thereafter. However, in staminate flowers, presence of non-functional pistil excludes the possibility of self-pollination. Thus, male fitness is selected to enhance pollen donation and is accordingly expected to show correlation between such traits and insect visitation[8]. In insect-pollinated plants (like *Brassica*, *Raphanus*, etc.) stronger correlation between male fitness-related traits (stamen–corolla length) seems to have evolved due to

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