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BIOSYMPHONICS: A CALL FOR MUSICAL EXPLORATION IN PLANTS

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Introduction

Behavioural changes in living organisms have been seen for a lager succession in evolution. Communications in ecology as a part of behavioural sciences is the most important studied topics. Earlier, communication studies were mainly focused on animals as their signalling and eye-catching interactions were most appealing and attracted the attentions. Plants communications has been considered as most controversial as their mechanisms of communication and interactions are completely different as compared to animals. Instead, this feature has attracted researchers for widespread exploration and attention.

Our widespread understanding of plant ecology and communication is specifically rotating around chemical and behavioural signalling. Plants signalling during drought and flood situations are good examples of plant chemical and behavioural interactions for example- the alarming signals during drought by garden pea (*Pisum sativum)* responds the stress cues neighbours by closing their stomata, which eventually reduces the stress for water and promotes the less nutrient uptake from the soil to decline the plant growth. This leads to decline in leaf size, less stem extension, and root proliferation which ultimately makes plant more palatable to herbivores.

The accurate and ultimate communication mechanism in animals to sense and respond to it by coordinating with others have been a long subject of intense interest to study and explore more. Whereas the plant communication mechanisms are not much advanced and recognised. Ultimately this is the case for bioacoustics in plants. This feature is

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phylogenetically not much progressive as compared to other organisms who have much advance sensory modality and behavioural organisation with their environment.

Bioacoustics is a branch of behavioural sciences associated with sound produced by organisms and their effect on other organism related to communications. Earlier, these bioacoustics aims at recording and studying the sounds that different animal species produce in their immediate environment. Instead, the audible sounds from plant leaves and sideways branches as raindrops touch them or winds swamps them, that plants generate their own symphony of sounds.

DO PLANTS MAKE SOUNDS AND DO THEY RECOGNISE IT?

Sound perception in humans is limited to audio frequencies in the range of 20-20000 Hz, and acoustic frequencies higher than this seems silent to us. Very low frequency <20 Hz are infrasonic and higher pitch sounds >20KHz are ultrasonic to both of which human ear is unable to detect. Sometime plants have been known to produce sound waves at the lower end of the audio frequency range of 10-240 Hz (audio acoustic emission) which is ultrasonic acoustic emission (UAE) ranges from 20-300 KHz. Since last 45 years these acoustics (UAE) have been measured and interpreted several times.

Acoustic released from plants are generally interpreted as a result of the release of tension from water transport system of the plant followed by cavitation since the water is pulled by suction force from roots to the leaves (as described in cohesion theory). This cavitation is caused due to the water bubble (embolism) dissolved with air, causing occluding in conduits and makes them unavailable to transport the water. These emitted acoustics are considered as an incidental process of physiological/biochemical activity, these are also sometimes considered as indicators of cavitation in drought stressed plants.

In a contradictory argument regarding these sounds states that these plant acoustics are not caused by cavitation disruption of the stressed water conduits, instead they are produced by a largely stable bubble system of the water conduits capable of peristaltic transport of water to the leaves. Although it is still an undisputed theory that cavitation can induce acoustic emissions and these signals are so numerous in plants that it directly points to the cavitation alone. In some recent research it has been found that sounds generated by plants independent of cavitation related process and dehydration.

WHY PLANTS PRODUCES SOUND, DOES THIS CONVEY ANYTHING?

Sound signalling in common sense is used to propagate information in real-time without any obstructions. Most importantly, these acoustic signals can be altered in ways to deliver instantaneous changes to be analysed instantly in low intensity and long distances. These acoustic signals are generated with very low energy investment as these energies are emitted by the biophysical processes. Due to this very nature, sound signalling offers a very impressive and effective mechanism for communication when a very instantaneous action/response is required. Since, the role and potential utility of these acoustics in plant to plant or plant to immediate environment communication remains an unexplored subject. By considering the physiological viewpoint, we can tackle this issue of communication with very sophisticated sensing network readily mediated by phytohormones, which initiate quick responses to neighbours or canopy shade (shade avoidance syndrome) and chemical defences to herbivore damages. Although these chemical hormones are potential point of interactions that overlaps pathways which are involved in competitive and defence responses, this also includes mechanoreceptor of pressure waves (i.e., sound acoustic).

Let's take an example of IAA (indole acetic acid), it is known to play a defence modulating response during wounding including initiating multiple changes in body plans, like stem elongation related to shade avoidance. The most interesting part is that the same hormone is also implicated in the mechanisms that mediate sound induced morphological modifications of the callus, that is required for facilitating rapid cell multiplication in wounded tissues. In the same manner a decrease in the levels of abscisic acid, that normally inhibits the stem elongation, has been speculated that the same hormone has resulted in sound-induced morphological responses to be facilitate above ground competitive ability.

Moreover, we can recall that bacteria also share communication strategy via ultrasonic sound waves, the idea that plants may talk via sound signals should no longer be adjudged as a research oddity.

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Does acoustic emission from one plant affect the behaviour of the surrounding plants?

Let's take an example of rodents to understand the ultrasonic utterance during physiological process and then we will understand the effect of acoustic emission on other plants. Infant rodents in extreme cold exposure responds with bradycardia, the behavioural arousal which results in emission of ultrasounds. In humans, the common disturbances like sneezing, wheezing and coughing produces some physical ailments, in the same manner in rodents also the production of ultrasounds by infants is not driven by any motive for communication acoustically, but instead it's just a result of reflexive physiological and biochemical process i.e., abdominal compression that results in the emission of sounds as by-product. These rodents have ability to propel blood back to the heart to maintain the cardiac out even when physiologically challenged. This process of emission of ultrasounds in pups during cold stress is just analogous to the cavitation process described for the drought stressed plants. In both cases the emission of ultrasound is just a mere by-product of physiological strain.

Now, we can answer the above-mentioned question more systematically. In above rodent's example the ultrasonic vocal emission by the infant elicits a phonotaxic response to the mother outside the nest. We cannot predict the proximate cause of signal emission but, these ultrasounds triggered the mother for behavioural response and benefitted the infant. Hence this signal transferred some information to the receiver which resulted in the behaviour change in much adaptive way which transcribes the genetic fitness of infant-mother system. The true communication system to be established may not require intention or benefits for all parties involved in it. So, in a nutshell we can conclude that a lot of information only travels one way and this is sufficient to make a living sustainable. These informations transferring mechanism and processes proved to be challenging in plants alone. An alternative approach may be required and we could pioneer that communication is not always a final accomplishment.

The Alarming Response

Since over few decades we started appreciating the plant chemical responses towards the insect attacks by using extensively produced volatile organic compounds. These plant-to-

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plant communication towards the infestation is carried out in air channels, these cues produced by the infected or injured neighbours to confront the non-infected plants from the insect. Instead, the plant responses are still limited to the chemical traits that does not include other modes of communications which are yet to be explored in depth. These responses including sound as its most influential signalling system mechanism for defence and communication.

The idea of plant acoustic emission may serve as short range deterrents and attractants for some attacking insect is not new as it was proposed earlier by *Mattson and Haack* (1987), in the year 2009 it was again presented by *Dunn and Crutchfield* in which he shown the emission influence and the behaviour of such insect as wood borers. Still after this there are many questions which are to be explored and answered, researches are going through with moist advanced equipment and technologies, yet interest towards the understanding is much needed.

CONCLUSION

The current lack of studies on plants and sounds prevents in concluding the true potential abilities of bioacoustics and its transmission at this stage. But we should also remember the event took place over 100 years where scientists disbelieved the data shown that bats orient themselves using the sound, which later on hampered the discovery of '*Laryngeal echolocation*' in these Bats (*Teeling*, 2009).

The birth of plant chemical ecology, unveiled the 'talkative' nature of plants and the sequel of their volatile vocabulary. The combination between ecology and chemistry has greatly advance our understanding of plant behaviours and its responses. This has now been serving as inspiration for the purposeful cooperation between disciplines that would likely help in the full exploration of acoustic world of plants. In short, all considerable evidence emerging from contemporary research in plant and allied sciences is now highly recognizing plants as highly sensitive organisms that can interact, asses and can actively acquire information from their immediate environment.

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