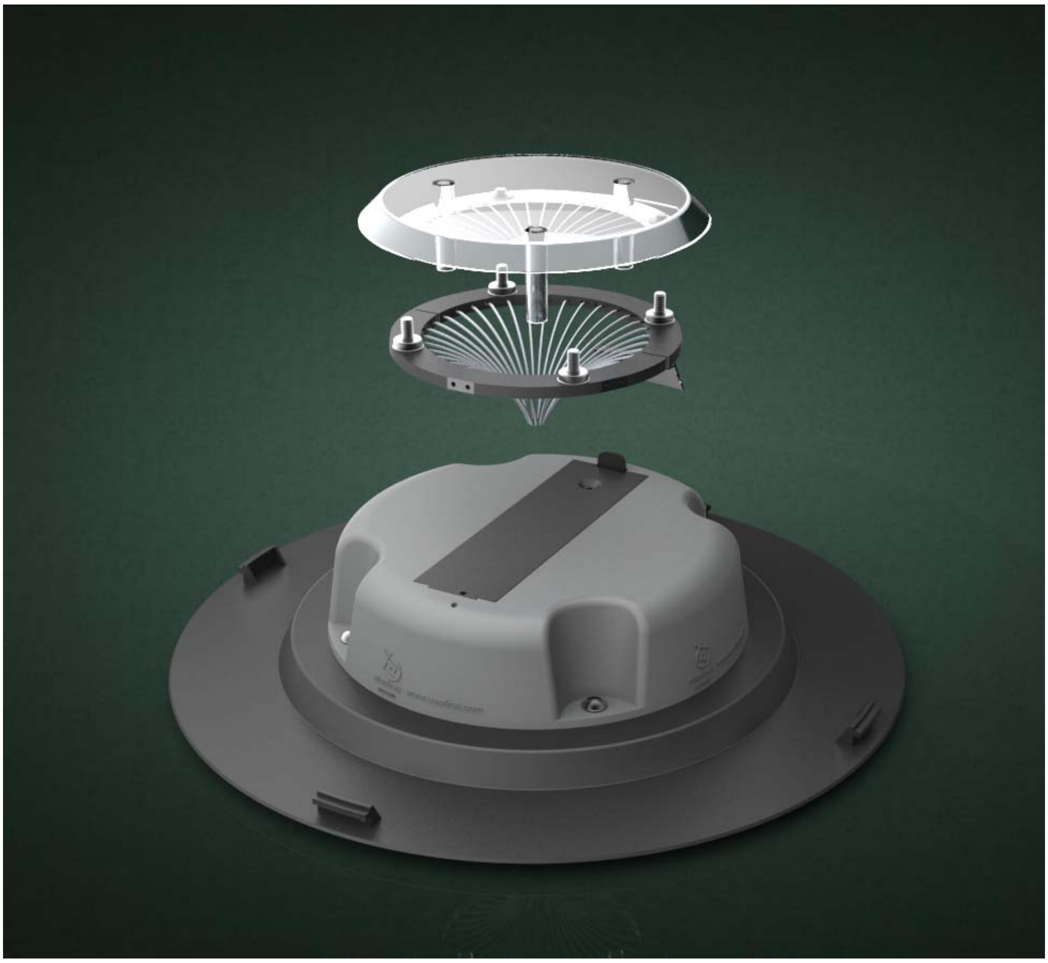
Electromagnetic Communication and Olfaction in Insects

Progresses in Studies and Applications on RPW Plague



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The importance of infrared radiation as a vehicle for the conveyance of information by "invisible rays" was recognized by the military early in World War II. The versatile Bell Laboratories physicist, Herbert E. Ives, developed the Sniperscope, which uses infrared light, and also developed infrared signalling between ships. Every object above a temperature of absolute zero (-273[degrees] C) radiates infrared wavelengths. Everything at the temperature of life radiates infrared. That is why we call it "the radiation of life".

Summary

The ongoing debate over the mechanism of primary olfaction has two opposed theories: according to some researchers, the olfactory epithelium reads the shape of odorant molecules; others assert that the electronic or vibratory aspect of the scent molecule is crucial.

Several recent studies, contrarily, demonstrate that insects "smell" pheromones an kairomones by tuning into their infrared emissions. Molecules do not need to interact physically: the interaction can be via electromagnetic field.

This study is the analytical approach to the field implementation of the most scientifically accredited theory and of its corollary consequences.

Introduction

Why is a moth attracted to a candle flame? The question has baffled many entomologists. A clue comes from the fact that a moth is attracted to a candle flame or to certain lights, but not to the light of a campfire (unless green wood is being burned). The English poet, Thomas Carlyle, attributed the moth's self-destructive behaviour to passionate love. In a way, Carlyle was correct.

After many years of fascination with the moth and the flame, scientific community decided that there must be something besides visible light coming from the candle. A candle is made of wax, and the insect is coated with wax. Perhaps heated waxes emit some unknown frequency that the moth can sense. Perhaps this frequency is in the infrared region. We shall see that careful research confirmed these ideas. Once sensitive spectroscopic technology became available, it was possible to confirm that the candle produces a wide range of infrared emissions corresponding to the emissions of pheromone/kairomone molecules.

Insect Communication

Insects have a fantastic ability to find specific mates, hosts and crops among the myriads of nature's species and the diverse attractant molecules they emit. These insect sex and food attractants are called, respectively, pheromones and kairomones, words from the Greek: pherein (to carry), kairos (the right or opportune moment) and hormain (to excite).

A problem with the pheromone/kairomone attraction hypothesis is that a male moth can find a female who is downwind. The breezes are carrying the so-called attractant molecules away from the male moth, and not toward him. This dilemma with chemical attraction in insects has similarities to the problem in homeopathy. There is a point in the dilution of a molecule, beyond Avogadro’s number, where there are essentially no molecules remaining in a given volume, yet a biological effect is still present. Entomologists and naturalists dating back to the early 18th Century had suggested the possibility that insects communicate by radiations emitted from oscillating molecules.

In 1894, a famous American entomologist, C. V. Riley, attributed the insect's remarkable sense of direction to some unknown communication system, which goes beyond scent and hearing. Riley referred to certain subtle vibrations that could be detected by a sense organ that does not respond to light of the same frequencies that our eyes can see, but that responds to other frequencies to which we are blind.

An equally famous French entomologist, J. H. Fabre, speculated in 1913 that the (then) recent invention of wireless telegraphy might have been anticipated by the Peacock moth, which can attract males from miles away, possibly by "electric or magnetic waves."

Other entomologists concluded that neither sight nor smell is sufficient to explain the attraction of the male moth from long distances. Many of these scientists concluded that insects must emit some sort of "special waves or rays" for long-distance communication.

In the more recent literature, a British electrical engineer, E. R. Laithwaite, had noticed that the moth antenna has a remarkable resemblance to a radar antenna. In 1960, Laithwaite wrote "A radiation theory of the assembling of moths." He also noted that a male moth can fly with the wind to find a female. Laithwaite concluded that there must be an electromagnetic attractant signal that travels independent of the wind.

I agree: the chances of a chemical molecule landing on the male antenna are far less than the chances of the antenna passing through the electromagnetic field emitted by the pheromone/kairomone and the shape of the moth antenna resembles that of a direction finder. Perhaps the insects are homing in on signals they detect by moving from side to side off the main beam, like pilots follow a directional beacon to an airport. Perhaps the zigzag flights of moths and butterflies are simply a scanning process, using direction-finding antenna arrays. Also Callahan found a variety of correspondences between the structures of various insect antennas and radio and microwave antennas.

The MASER

Charles H. Townes, who received the Nobel Prize with Arthur L. Schawlow for the invention of the laser, observed that Microwave Amplification by Stimulated Emission of Radiation (MASER) is common in nature. Oscillations from molecules can be coherent. Townes had noted that some gases oscillate very readily in the infrared region. It is easier to obtain fluorescence in the infrared region (particularly the far-infrared) because the energies (in terms of electron volts) are lower than for the shorter and more energetic wavelengths in the visible and ultraviolet region.

Visible light from the sun can "pump" or energize the vibrations of scent molecules so that they fluoresce. The night sky is illuminated by light from the moon and from the 3,500 or so bright stars that emit in the infrared region only. This light is invisible to us. The infrared light at night is energetic enough to "pump" scent molecules to fluoresce in the far-infrared region of the spectrum. These molecules need not be contained in sealed tube and be pumped by high voltages, as in a laser. Instead, they can fluoresce naturally as they float through the air, pumped by the natural light sources mentioned above. These emissions are then collected by sense organs such as insect antennas, which are tuned directional resonating systems.

After reviewing all of the literature and suggestions, I agreed that:

- the insect sensory mechanism is both infrared and olfactory;
- insects "smell" odours electronically by tuning into the narrowband infrared radiation emitted by sex, preys, and host-plant scent molecules;
- molecules do not need to interact physically with receptors;
- the interaction can be via the electromagnetic field.

This phenomenon is now recognized by a number of entomologists as being involved in the ability of insects to locate mates, host plants, host mammals (e.g., ticks and mosquitoes), birds, and prey (e.g., spiders).

The Experiments

The most telling evidence that insects use infrared communication systems comes from studies done in Tifton, Georgia. A six-watt blacklight bulb was enclosed inside an infrared filter that completely removed visible and ultraviolet, while passing infrared light with wavelengths from 1 to 30 [micro] m.

This "trap" was placed in a 15' x 15' walk-in cold room set at 65 [degrees] F. Each night, for five successive nights, he released 100 male armyworms into the totally dark room with the trap. At the end of a week, only 7% of the moths had entered the trap. The infrared radiation by itself was not the attractant.

In another week of experiments, two virgin female moths were placed in the trap each night and the armyworm moths were released into the room as before. During this second week, 98% of the male moths were in the trap.

During a final week of experimentation, the females were placed in the trap, but the light was not turned on. No male moths entered the trap. Clearly neither the pheromone/kairomone nor the infrared light alone is the attractant. It is the combination of infrared radiation and pheromone/kairomone molecules released by the female moths that powerfully attracts the male moths.

Another aspect of insect behaviour that has fascinated entomologists is the constant rubbing and cleaning of the antenna by all species of insects. Researchers suspected that such rubbing by a female moth might amplify the outgoing infrared pheromone/ kairomone signals and thereby facilitate the detection of the message by the male moth. The proposed mechanism was that the rubbing spread the scent molecules uniformly over the sensilla surface and the more uniform spacing then enabled the female to emit the signals coherently, analogous to the mirrors at either end of a gas laser. When a thin layer of pheromone/kairomone was placed on a beeswax plate, spreading it out by rubbing with a silk cloth, and modulated it at 55 cycles per second, the narrowband MASER-like line was detected .

Research has shown that almost all scents operate by stimulation of the C=H double bond. Both light and low frequency sounds (such as the buzzing of a mosquito) can vibrate or "stretch" these C=H bonds in such a manner that the scent molecules emit in the infrared region. For example, ants emit sound around 5 Hz (this is caused by the rapid tapping of their antennas on the ground or on the antennas of other ants). This tapping stimulates emissions by scent molecules the ants lay down to create trails so they can follow each other. When they greet each other, ants can distinguish animals from the same colony by the stimulated emissions from the Dufours gland, which contains a recognition substance. Bees, mosquitoes, flies, crickets, and locusts each emit specific frequencies by the beating of their wings. The stories of the ways these insects use these sounds to stimulate scent molecules in their environment is one of the most fascinating tales of natural history. This research is an example of how much can be learned by combining the keen eye of a naturalist with sensitive biophysical measurement techniques.

Orienting Behaviour

How the male moth orients as he approaches the female? An insect warms its body by beating its wings. The metabolism of the thoracic muscles warms the body surface and the thermal energy is radiated in the infrared region. A moth beating its wings has a surface temperature as much as 8[degrees] F above its resting temperature.

A female moth receptive to mating sits in one spot and vibrates her wings. Night-flying male moths seek their mates at night when the ambient temperature is around 65[degrees] F. The surface of the vibrating moth is not at 65[degrees], but is at about 73[degrees]. Using Wien's formula, we can determine that the background infrared radiation of the earth and leaf surfaces at 65[degrees] F peaks around 10.34 [micro] m, whereas the moth stands out against this background because it is radiating at 9.88 [micro] m. To another organism able to "see" in the infrared region, the female moth stands out like a beacon against the background.

Moreover, the beating of the wings up and down across the warm thoracic region of the female moth's body modulates or "chops" the infrared signal, so the male, sensitive to the infrared, sees a flashing or flickering beacon. The extent of the flickering depends on the male's orientation with respect to the female. Head and abdomen put out little radiation, whereas the thorax emits strongly.

Again, the flickering effect using a pyroelectric infrared detector made of a crystal of triglycinesulfate has been confirmed. The signal emitted by a moth beating its wings varied in intensity, depending on the angle between the insect and the detector. The different oscilloscope traces obtained with the pyroelectric detector at different angles from the female moth showed two peaks in the tracings in the upper right and lower left and notches: these double and notched peaks arise because the female moth has two wings on each side, and these wings can twist or change their pitch independently of each other. The relation between the peaks gives the approaching male moth information on his azimuth in relation to the female, and on his angle of approach. Callahan compared this insect navigational system with the instrument landing systems (ILS) developed by the United States Air Force to enable planes to land under conditions of poor visibility.

Waiting for Technology

In some cases, obvious experiments had to be postponed until the appropriate instrumentation became available. The evolution of laser technologies, and thinking deeply about how laser and

MASER-like systems might function in nature were patiently watched One of the first fast Fourier transform (FFT) spectrophotometers from Digilab, when they first became available in 1970, was used as instrument to demonstrate that the infrared output from pheromone/kairomone samples is greatly increased when the samples are vibrated with sounds similar to those made by insects. In the early years of his research, it was difficult to generate pure infrared signals. But the researchers were ready to test the effects of pure IR on insect behaviour when good sources became available.

Candle Flames, Green Wood, and an Irish Singer

In his experiments, using the FFT spectrophotometer, Callahan was able to demonstrate that paraffin and beeswax candles emit many narrowband infrared frequencies between 2 and 30 [micro] m. He observed the cabbage looper male protrude his claspers toward the flame-something the moth normally does only in the presence of a pheromone/kairomone from a female of his own species. The candle flame emits almost the exact same narrow 17-[micro] m frequencies as the pheromone. The flickering of the flame also modulates the candle radiation to produce a chopped ILS-type signal as described above. The male moth is convinced he is approaching the love of his life, as Carlyle suggested.

The moth is attracted to the campfire when green wood is being burned. Callahan learned that this attraction is due to the thousands of infrared frequencies emitted from the heated hydrocarbon gases extracted from the green wood by the intense heat. Emissions of chlorophyll are particularly attractive. Seasoned wood lacks chlorophyll and is of much less interest to the moth.

While Callahan has retired from his successful research program, he continues to observe nature and report his findings in his books. For example, in Nature's Silent Music he describes a moth in an Irish pub spiralling in front of a singing Irishman. The moth is attracted to the singer's breath. The alcohol in his breath is "doped" with ammonia, and the combination, when "pumped" with low frequency sound, emits strong infrared emissions that resemble those of certain plant scent molecules.

Different Species, Different Codes

The narrowband frequencies that would fit into the atmospheric windows between 2 and 30 [micro] m would provide more than 930 different infrared "radio" channels available to code information on different species of insects, prey animals, and food crops. When one considers the millions of insect species in nature, this infrared-coded scent system provides a logical mechanism for recognition and communication. The infrared frequency band is the largest part of the electromagnetic spectrum, occupying some 17 octaves, in contrast to the single octave in the visible spectrum.

A familiar example of infrared technology is the remote control we use every day to operate our televisions. Each channel and each function has a code that is communicated as a low power pulsing infrared beam. Nature invented this trick long ago.

Theoretical Conclusions

A consequence of ancient thinking, dating to Democritus, Epicurus, and Lucretius, is that all matter is composed of "imperishable" atoms, tiny indivisible particles that can neither be created nor destroyed. “Billiard-ball” units, atoms or molecules, move in straight lines in all directions, in accordance with the iron laws of "necessity" that were eventually replaced with Newton's Laws of Motion. Interactions cannot take place between atoms or molecules unless they touch one another.

These ideas were pivotal for the development of Western science. A legacy of this natural philosophy is the modern molecular view of regulatory interactions in which signal molecules such as hormones or neurotransmitters or pheromones diffuse, wiggle, and bump about randomly until they chance to approach an appropriate receptor site, at which point electrostatic and other short-range forces draw the signal molecule into the receptor, much like a key fits into a lock. The "key" obviously has to have a structure or shape that matches the "lock." For this model, shape is crucial.

We now know that atoms are not solid and indivisible, and we also know that the "lock and key" model is an incomplete picture of regulations. The random meeting between hormone and receptor, or enzyme and substrate, taking place in a sea of other randomly moving molecules, has a statistical probability approaching zero. Under these conditions, the simplest biological event or regulatory process should require some thousands of years to take place. Albert Szent-Gyorgyi recognized years ago that life is simply too fast and too subtle to wait for molecules to wander around aimlessly until they happen to bump into the right targets. Electromagnetic signalling is not only physically possible; it is the ideal mechanism for communication in living systems. For this model, electromagnetic resonance, not shape, is crucial.

The lock and key model is so easy to visualize and so deeply ingrained in our scientific culture that many have had difficulty comprehending energetic interactions in which molecules interact by co resonance, like radio transmitters and receivers. In living systems, as in radio and television, long-range electromagnetic fields exchange messages across distances because of matching emission and absorption spectra. Non- resonating, unwanted random signals are excluded simply because they do not resonate. All of this is fully consonant with the laws of physics. Resonance is a truly remarkable phenomenon, but it is not magic.

Infrared signalling has many applications beyond insect communication. The concept of bio-electromagnetic communications is receiving increasing attention in the scientific community. For example, see Bioelectrodynamics and Biocommunication by Ho, Popp and Warnke and a series of studies on cellular infrared cellular "vision" by Albrecht-Buehler. Over the years scientists who have published in Frontier Perspectives have written a number of key papers on this topic. As examples, see the work of Benveniste, Smith, and Popp.

The research with insects has obvious and fundamental implications for regulatory biology, energetic therapies, and environmental electromagnetic effects. Its findings also have deep significance for the current debate over the mechanism of primary olfaction, which has split into two camps-those who assume that the olfactory epithelium reads the shape of odorant molecules, and those who suggest that the electronic or vibratory aspect of the scent molecule is crucial. An engrossing popular book on this topic, The Emperor of Scent, documents the pervasive influence of the lock and key or "shapist" model in primary olfaction, in spite of many inconsistencies in structure-odour relationships.

Practical Conclusions

Using the aforesaid concepts, it is nowadays available a revolutionary device, ELECTRAP®, and here is a short description about it works.

As exposed, there is no evidence whatsoever that physical contact ever occurred between the scent (i.e. an insect Pheromone and Kairomone) and the purported receptors (odorant receptor proteins found on the dendritic membranes). Instead, detection might be occurring at a distance which suggests electromagnetic effects may be mediating this whole process. Therefore, vibrational frequencies became the prime candidate for an alternate theory.

If these vibrational frequencies are involved, then theoretically, smell can be both amplified and squelched. Both of these phenomena have been successfully demonstrated in the laboratory, and ELECTRAP® capitalizes on the former.

Specifically, the breakthrough discovery revealed that placing a scent in a highly reflective cavity resulted in heightened activity among Palm Red Weevils.

Over 4,000 experiments have been completed to date, and the surprising results are telling us that the efficiency is increased more than 300% whilst the management cost is reduced by more than 50%.

In fact, as a matter of an example, the Pheromone and Kairomone lures last for lengthily periods of time. There's no need to replace the Pheromone and Kairomone lures according to manufacturer's recommendations.

The ELECTRAP® is considerably more sensitive than the standard traps on the market. After an immediate impact, over a few short seasons it can exercise complete control.

- **Efficiency**
  - The "bucket" traps attract approximately 13% of the RPW under laboratory conditions.
  - Under the same conditions, ELECTRAP® capture over 80%.
- **Inexpensiveness**
  - Based on five years timeframe, the global cost of a traditional system is 170% more expensive than an ELECTRAP® system, the lifespan of a well maintained device being more than 10-15 years…
  - Due, inter alias, to the overcoming of the critical necessity of water provision, the needed manpower for basic maintenance is radically reduced by, at least, 60%.
  - Pheromone and Kairomone lures will last up to a year in our trap with virtually no loss in efficacy.