

Critique of the 1977 debate on infra-red 'olfaction' in insects — (Diesendorf vs. P.S.Callahan)

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Abstract

During World-War-2, the entomologist P.S.Callahan noticed a remarkable similarity: — The shapes of the various *radar aeriels* closely resembled the various spines etc. on insects. From 1965 onwards, he promoted the idea that insects often detect pheromones via *infra-red* as a scaled-down equivalent of those radar microwaves — with the pheromone-molecules acting as transponders or sites of fluorescence (all invisible to us). This notion was supposedly demolished in a 1977 debate within a single issue of the *International Journal of Insect Morphology and Embryology*.

However a recent detailed review of that debate (www.wbabin.net/physics/traill7) has shown up the logic-flaws on both sides of that contest, and hence come to new conclusions based on the same experimental evidence:

(1) That the evidence *does* support Callahan's *main* thesis involving infra-red "beacons".

(2) That it is vital to distinguish between long-range effects (>100 yards, for which there is no credible alternative mechanism anyhow), and short range (where orthodox olfaction is a confounding factor).

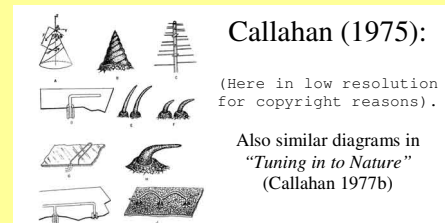
(3) A new interpretation of an anomaly within Callahan's sets of results, suggests that insect brains may sometimes process infra-red signals *directly* via dielectric paths (thus *bypassing the expected action-potentials!*) That could be much more efficient, and might help to explain the surprising memory capacity of bees etc.

(4) It is a matter of public concern that significant interdisciplinary work like Callahan's should be so promptly dismissed on inadequate grounds — even if his own presentation had its failings. Was it all too technical and therefore threatening, or what?

If infra-red signal patterns really do have such pheromone and kairomone roles, that may open up new possibilities for non-chemical arthropod control.

1940s: P.S.Callahan noticed — (during W W 2):

- #1 [✓] Radar-aerials have various odd shapes — which closely resemble the spines etc. **on insects!** (In fact he later claimed this is true for all 15 types of dielectric aerial!)
This strongly suggests a similar role:
Nature ≈ Human-Design



1960: E.R.Laithwaite (a Professor of Engineering):

- #2 **Q:** Many ♂ moths were known to be locating mates miles away. **But how?**

The key question here

- #3 [✓] Laithwaite showed there are at least 2 quite different navigation methods:
 (i) Short range = orthodox olfaction (uncertain direction, chasing pheromone itself).
 (ii) Long-range (>"100 yards") → Clearcut direction, even if wind stops all pheromone from reaching ♂ — so there must be a separate extra mechanism.
- #4 [✓] L. concluded that the long-range effect must depend on infra-red (IR) signals.

But problematic features:

- #5 **Q:** In ♂, **which organ might receive** such IR signals?
- #6 [?] L. assumed such reception would be via the antennae.
- #7 [?] If antennae *are* the receivers, then their size implies *long* IR wavelengths (>20 μm)
- #8 **Q:** What is it about the ♀ that **generates the following signals:**
 (i) "I'm receptive", *and then*
 (ii) "Sorry, you're too late!"
 — transmitted too quickly for any diffusion explanation **via carrier-molecules!**
- #9 [?] L. assumed the signals were emitted from the ♀'s body (as if IR glow-worms), and perhaps independent from pheromone emission.
- #10[X] L. overlooked the possibility of fluorescence from pheromones (even though he did discuss attractant fluorescence from water drops — in a rather different context, as an aside!). Cf. #15.

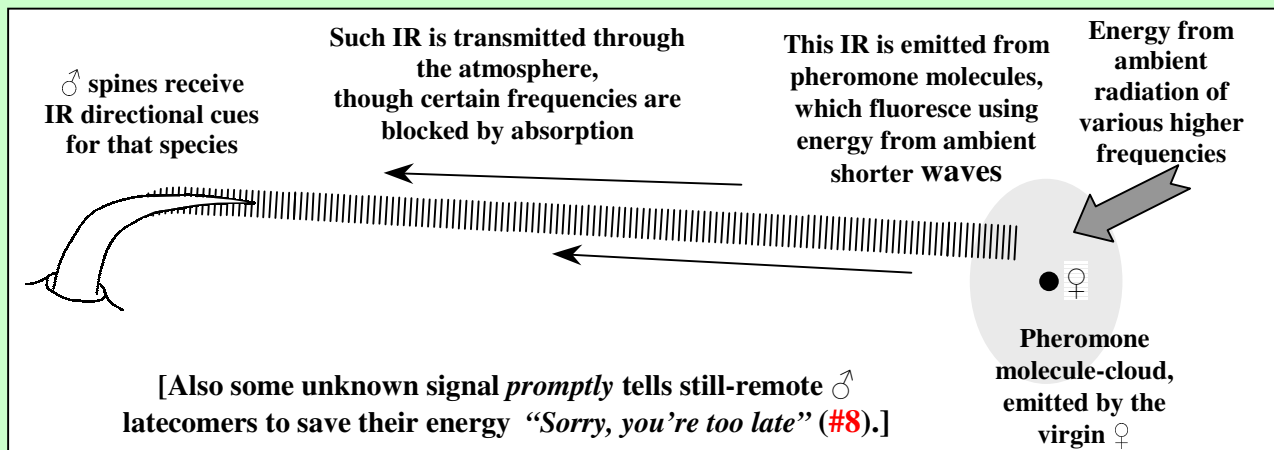
1967-1977: Callahan (an Entomologist, then at USDA)

- #11[✓] C. welcomed Laithwaite's support for infra-red (IR).
- #12[✓] Invoking his WW2 spines etc. (#1 above), C. increased the list of receiver-options beyond Laithwaite's one-off antenna-suggestion (#6).
- #13[✓] These alternative smaller aerials implied shorter IR wavelengths (1-20 μm) — more useful.
- #14[✓] C. showed that the actual spine-lengths tallied only with those IR wavelengths which can travel through the air (without being absorbed by it).
- #15[✓] C. amply demonstrated fluorescence-generated IR, and moths' attraction to it.
- #16[✓] C. argued that the energy-input for this fluorescence came from abundant ambient radiation of higher frequencies — even at night. Of course UV gives a particularly strong effect with its high frequency.
- #17[✓] C. argued the case for “stimulated emission” (Einstein 1917, Townes 1965) as adding to the fluorescence (and as a weak gesture towards laser-like activity).
[Useful but perhaps non-essential.]
- #18[✓] He also argued that, as the frequency generated collectively by stimulated emission will depend on pheromone concentration, this is therefore a means for detecting gradients.

But problematic features:

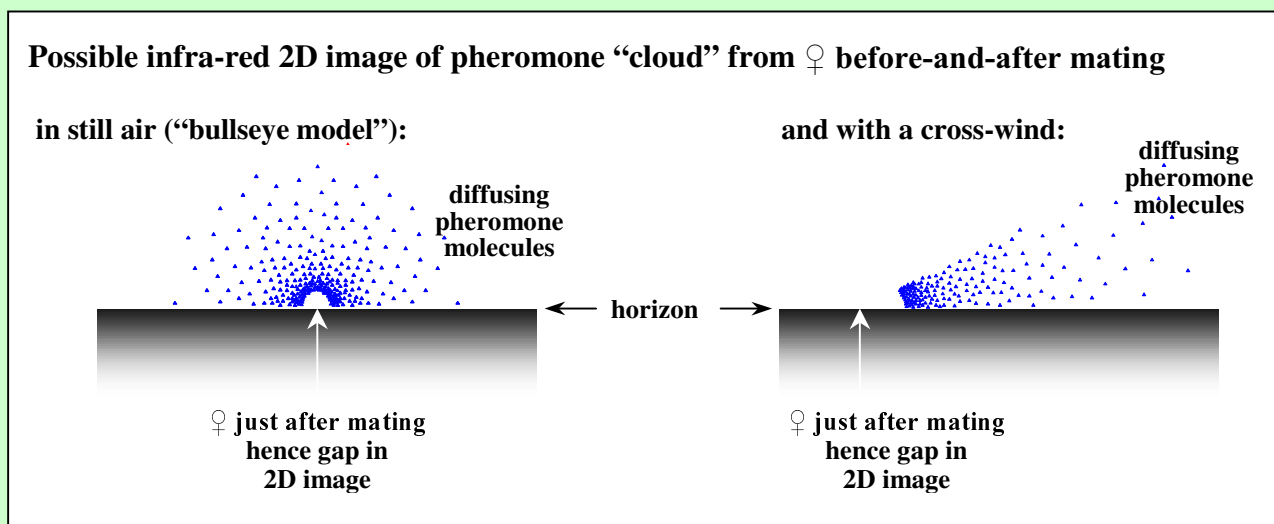
- #19[X] He quite **overlooked** Laithwaite's Long/Short-Range distinction (#3)! — So he tried to impose his IR ideas onto all-or-most Short-Range effects. Not totally unreasonable, but on shaky ground — and irrelevant to the Long-Range case.
- #20[X] He saw the stimulated-emission gradient (#18) as *the* key navigational mechanism — despite Laithwaite's convincing argument against gradients for Long-Range. Indeed C. even asserted that L.'s experimental evidence must be wrong!!
- #21[X] C. made several “amateurish” mistakes in his physics details, (e.g. units, terminology, etc...), not critical in themselves, but prejudicial to his case.
- #22[?] **Anomalous finding:** C's experiments showed *behavioural* response to IR, but he was unable to find any intervening *action-potential* in the nerves! (And yet there was no such problem for *visible* light!) — Also see #32 below, and the “conclusions”.

The Basic Logical Solution to the Cited Experimental Findings:



Some possible enhancements to that basic solution:

- #23 [?] **Arrays** of spines etc. Callahan pointed to the need for whole arrays of aerials (as in Radio-Astronomy), especially for enhancing direction-finding and image-formation. Clearly the spines on insects are available as arrays.
- #24 [?]* The “Sorry, you’re too late” message (#8) may be a separate “anti-pheromone” molecule-type and its IR emissions. — **Or:**
- #25 [?]* This information may come from the shape of the IR image if it can be “seen” in 2D. Thus:



* Post-conference critique about “cancellation” of the pheromone signal:

If we see this prompt cancellation-effect as mysterious, it is probably because we are still *assuming a key role for diffusion* — that very slow process — at least in setting up an identifiable “cloud shape” (#25 above), or perhaps as something more orthodox. **However**, if fluorescence *is* the main mechanism, this will probably be occurring mainly where the pheromone-cloud is most concentrated — *very close to its ♀ source* (though not actually at the source herself as Laithwaite assumed). Hence when the female stops emitting the pheromone, that local high-concentration will fairly quickly disperse, and the most effective part of the IR-emission would also cease. Thus the above suggestions #24 and #25 are probably both superfluous, though they might still offer contributory cues for some species.

RRT (21 October 2008)

The 1977 debate between Diesendorf and Callahan:

This debate was a mess; with political point-scoring, and no editorial.

Callahan's shortcomings (incl.#19-#22) were paraded, while his-and-Laithwaite's achievements were brushed aside; so he was deemed to have lost the "battle". Hence the whole idea of IR communication was dropped, despite the unresolved issues.

- #26[X] Neither C nor D mentioned Laithwaite's distinction between Short and Long Range!!!!
- #27[X] So both got bogged down on Short-Range issues : — (arcane unresolved topics such as: signal-chopping, $d \ll \lambda$ in bipole theory, and orthodox olfaction-mechanisms — all being of dubious relevance).
- #28[X] Both wasted effort discussing unlikely alternative energy sources (such as "rubbing", and "black-body radiation").
- #29[X] Both wasted effort discussing possible optical-coherence of the signals (probably irrelevant!) — largely because Callahan tended to confuse "coherence" with the vital "monochronicity"!!!!
- #30[X] Likewise they argued unproductively because Callahan had not made it clear what he meant by "maser-like". Was he concerned with production of:
 → Coherence? (irrelevant, #29)? — or —
 → Amplification? (non-basic, #17)? — or —
 → Gradient-measure? (Short-range, and not necessarily basic, #18)?
 And with no efficient reflectors, the effect could only be relatively weak anyhow.
- #31[?] D objected that thermal-IR background would drown those signals with wavelengths $> 4 \mu\text{m}$; but that need not apply fully if the signals were narrow-band and "loud" enough.
- #32[?] Anomaly of the missing **action-potential** (#22) after IR stimulation, while still getting a behavioural response. — Diesendorf saw this as a fatal flaw! Callahan didn't!
 One logical resolution is to postulate a different extra peri-neural transmission-mode — see the "Conclusions".

Further information, including extra references:

<http://www.ondwelle.com/OSM03.pdf> (This topic);
<http://www.ondwelle.com> (Related works)

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Conclusions:

- ♣ Laithwaite was right in believing there are **at least two odour-detecting mechanisms**, and that the one for **Long-Range involves infra-red**.
 - ♣ Callahan was right in identifying many insect **sensillae as the aerials for infra-red signals**; but he exposed himself to criticism by careless presentation, and inadequate self-defence.
 - ♣ Diesendorf identified some of Callahan's failings, but overlooked the possibility of important truths hidden under the confusion. He also virtually ignored Laithwaite.
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- There are three plausible explanations for the mysteriously rapid “anti-pheromone” (“*too late*”) signal:
 - (i) a hypothetical “antidote” system; (ii) the promptly altered “bullseye-or-wedge” geometry of the IR-emitting pheromone-cloud; — &/or more likely [*added post-conference*]:
 - (iii) most of the effective fluorescence will occur fairly close to the female, and hence will soon dissipate when she stops producing the pheromone.
 - The “missing **action-potential**” (#22, #32) might be explained if we accept that axons sometimes serve as optic fibres for infra-red, as was postulated independently for mammals (Traill, 1978 Part B).
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- ▶ The scientific community was remiss in allowing this topic to be buried prematurely — and that is a matter of some social concern.
 - ▶ This avenue could well open up new possibilities for arthropod-control.

Main References:

- Callahan, P.S. (1967) “Insect molecular bioelectronics: A theoretical and experimental study of insect sensillae as tubular waveguides, with particular emphasis on their dielectric and thermoelectret properties”. *Miscellaneous Publications of the Entomological Society of America* **5**(7), 313-347.
- Callahan, P.S. (1975) “Insect antennae with special reference to the mechanism of scent detection and the evolution of the sensilla” *International J. Insect Morphol. and Embryol.* **4**(5), 381-430. — “/1\” — **Main target of Diesendorf's attack**
- Callahan, P.S. (1977a) “Comments on Mark Diesendorf's critique of my review paper” *International J. Insect Morphol. and Embryol.* **6**(2), 111-122. — “/3\”: **part of the debate**
- Callahan, P.S. (1977b) *Tuning in to Nature*. Routledge & Kegan Paul: London. [an informal account for general readership].
- Diesendorf, M. (1977a) “Insect sensilla as dielectric aerials for scent detection? Comments on a review by P.S.Callahan” *International J. Insect Morphol. and Embryol.* **6**(2), 105-109. — “/2\”: **part of the debate**
- Diesendorf, M. (1977b) “The ‘dielectric waveguide theory’ of insect olfaction: a reply to P.S.Callahan” *International J. Insect Morphol. and Embryol.* **6**(2), 123-126. — “/4\”: **part of the debate**
- Einstein, A. (1917/1967) “On the Quantum Theory of Radiation”. In D. ter Haar (1967) *The Old Quantum Theory*. Pergamon; p167-183 — [Originally (March 1917): “Zur Quantentheorie der Strahlung”, *Physikalische Zeitschrift*, **18**, 121-128.]
- Laithwaite, E.R. (1960) “Radiation Theory for the Assembling of Moths”. *The Entomologist*. **93**(1165 June), 113-7, and **93**(1166 July), 133-7, +plate.
- Townes, C.H. (1965). “Production of coherent radiation by atoms and molecules”. *Science*, **149**(3686), 831-841.
- Traill, R.R. (1978/2006). *Molecular explanation for intelligence...*, Thesis, Brunel University: <http://hdl.handle.net/2438/729> (2 files) — or Ondwelle Publications: www.ondwelle.com (7 files)
- Traill, R.R. (1988). “The case that mammalian intelligence is based on sub-molecular memory coding and fibre-optic capabilities of myelinated nerve axons”. *Speculations in Science and Technology*. **11**(3), 173-181.
- Traill, R.R. (2005c). *How Popperian positivism killed a good-but-poorly-presented theory — Insect Communication by Infrared*. Ondwelle: Melbourne. www.ondwelle.com/OSM03.pdf — Also in *Gen.Sci.J.* www.wbabin.net/physics/traill7