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 aerials 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/trail17) 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.
Critique of 1977 debate: Diesendorf vs. Callahan

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?

#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 high 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:

<table>
<thead>
<tr>
<th>Spines receive IR directional cues for that species</th>
<th>Such IR is transmitted through the atmosphere, though certain frequencies are blocked by absorption</th>
<th>This IR is emitted from pheromone molecules, which fluoresce using energy from ambient shorter waves</th>
<th>Energy from ambient radiation of various higher frequencies</th>
</tr>
</thead>
</table>

[Also some unknown signal promptly tells still-remote ♀ latecomers to save their energy “Sorry, you’re too late” (#8).]

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:

Possible infra-red 2D image of pheromone “cloud” from ♀ before-and-after mating

in still air (“bullseye model”):

and with a cross-wind:

* 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.

FRT (31 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<\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 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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Conclusion:

♦ Laithwaite was right in believing there are at least two odour-detecting mechanisms, and that 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. (1977a) “Comment on Mark Diesendorf’s critique of my review paper” International J. Insect Morphol. and Embryol. 6(2), 111-122. — "part of the debate"


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. — "part of the debate"


