IN SUPPORT OF REAL ENVIRONMENTS

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ABSTRACT
Organisms have evolved in environments in which changes in physical, chemical and biotic factors create huge complexity in time and in space. While the "real world" may not be the most attractive stage on which to perform experimental science, we cannot hope to understand the multiplicity of factors, which regulate fundamental processes if we reach conclusions, based solely on simple manipulations of variables. Examples will be cited to point out the kinds of misunderstandings that can occur as a result of "simple" experimentation which neglects the complexity encountered in an uncontrolled, or partially controlled, environment. The German word "gestalt", defined in Webster's dictionary as "a structure, configuration, or pattern of physical, biological, or psychological phenomena so integrated as to constitute a functional unit with properties not derivable by summation of its parts", points clearly to the perils that may be associated with "simple" approaches which are, in effect, "shallow". On the other hand, there are sound and robust reasons for employing experimental methods in which the term "simple" is synonymous with "manageable".

The full presentation is not available. Just a few of the examples introduced during the talk are provided here in abbreviated form.

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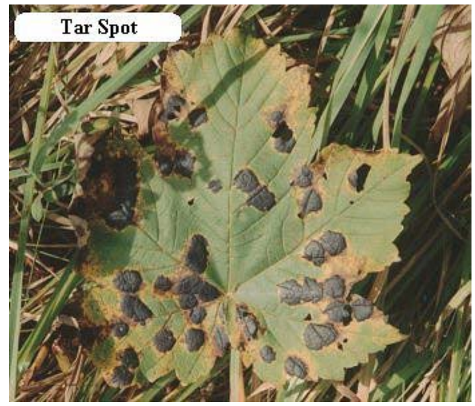
1. Environmental factors affecting the disfiguring disease known as Tar Spot on sycamore trees (*Rhytisma acerinum* on *Acer pseudoplatanus*).

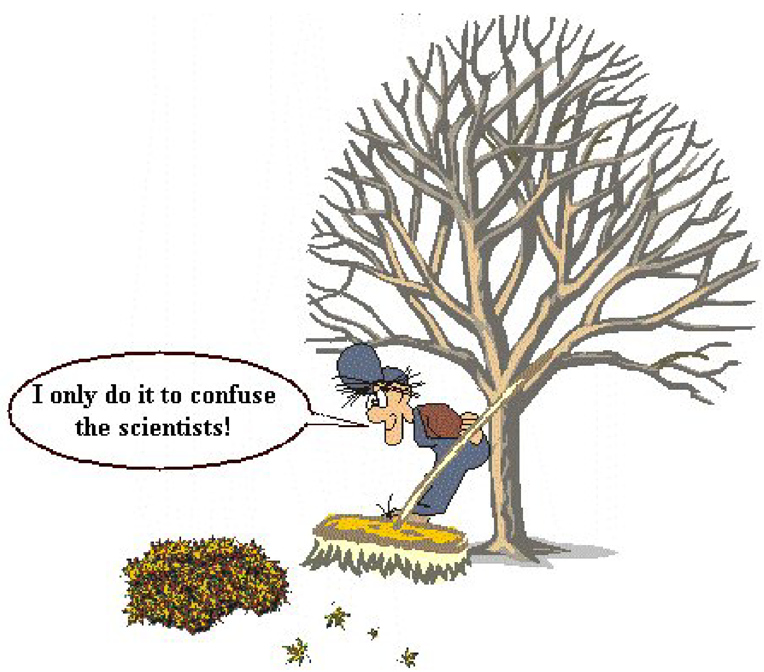
Saunders (1966) showed clearly under laboratory conditions that low concentrations of SO_2 are highly toxic to the pathogen *Diplocarpon rosae* which causes Blackspot of roses. The low abundance of the disease in urban areas was proposed, and quite widely used, as a convenient biomonitor for SO_2 pollution.

Tar Spot on sycamore produces very similar visible symptoms to those of Blackspot, and like the latter it is less common in urban than in rural environments. Twelve years after the work of Saunders, Greenhalgh & Bevan (1978) inferred a causal link between inhibition of *R. acerinum* and air pollution, based on the data for Blackspot of roses, without experimental evidence. After publication of this paper, many people started to use the prevalence of Tar Spot as a means of biomonitoring for SO_2 pollution.



Leith & Fowler (1987) found that Tar Spot was virtually absent from trees in the city of Edinburgh, though abundant in the surrounding rural areas. There was, however, no correlation whatever with SO_2 concentration. Fallen leaves as sources of inoculum were the important factor, and in the city, leaves were swept up in the autumn.

This story provides a salutary lesson — we need to have knowledge of a whole range of environmental factors before drawing conclusions that may be far-reaching in their importance.



2. Why is Salt Cedar such an invasive species?

Native riparian trees (those living or located on the banks of natural watercourses) are much valued in the USA, but many are under severe competitive pressure from an exotic species, *Tamarix chinensis*, known as Salt Cedar. For a long time there have been many theories, but there has been little real advance towards explaining just why this species is more successful than those it is replacing. Genuine progress does now seem to be have been made as a result of a study by Horton, Kolb, & Hart (2001). They monitored physiology and growth during 1997 (dry) and 1998 (wet) years, looking at three riparian plants:

Native species	Exotic species
Populus fremontii	*Tamarix chinensis*
Salix gooddingii	

Physiological sensitivity to water stress in 1997 was similar in all species, but when ground water level fell below 2.5-3.0 metres, canopy dieback was less in *Tamarix* than in the native species. However, a further major factor behind the success of *Tamarix* was revealed in the wet year, 1998, when it showed a much larger increase in photosynthetic gas exchange than the native species, i.e. it recovered faster after the drought

Two factors are therefore involved in the competitive ability of *Tamarix* in riparian ecosystems: maintenance of viable canopy in dry years, and quick recovery to high physiological activity in wet years.

The combined significance of these factors could only be revealed during long-term studies of the plants' responses to the very extreme conditions of a riparian ecosystem. The occurrence of very dry conditions in 1997, followed immediately by a wet year, provided information of a kind that would be very difficult to obtain within a controlled environment.

3. The problems of evaluating what is occurring below ground.

Perhaps the strongest criticisms directed at studies of plants in controlled environments are concerned with the nature and the volume of the “soil” in the containers in which the plants are growing. Even outside in an ecosystem, however, the problems persist because it is very difficult to ascertain precisely what is happening below ground, and there are many examples where superficial observations have been misleading. One example brought to notice in the recent literature concerns the question: does increased nitrogen deposition reduce biodiversity of ectomycorrhizal fungi? Impact assessments based on production of visible sporocarps above the ground have suggested that there is a major loss of below-ground biodiversity. However, PCR-RFLP analyses to estimate below-ground populations have recently shown that there may not be a *quantitative* change in biodiversity at all. Additional N did lead to changes, but not as had been deduced by the superficial counting of sporocarps in the field. Instead Peter *et al*. (2001) have shown that it causes a shift in ectomycorrhizal abundance from species forming large sporocarps to those with inconspicuous, or no, sporocarps.

CONCLUSIONS

These two quotations, addressing the complexity of determining the impacts of CO_2 enrichment, both contain a few words which should become a “catchphrase” for all who work with plants in controlled environments:

“Every beginning biology student knows that photosynthesis will increase if you give a plant a ‘squirt’ of CO_2 —— given enough light, nutrients and water, and a suitable temperature. Logic tells us that if this is so, then more CO_2 in the atmosphere should mean more photosynthesis. This, in turn, should mean more yield or accumulated carbon in plants. This logic is fine for beginning biology; unfortunately, nature is not that simple”. [Lemon (1983)]

“…we should not expect a bog and a desert, nor a wheat field and a tree plantation, to respond identically to CO_2 enrichment ——nature is not that simple”. [Norby *et al.* (2001)]

Nature is not that simple!

REFERENCES

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