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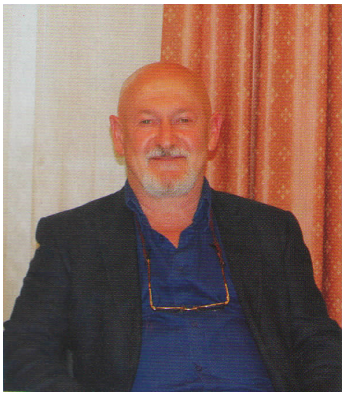

Thoughts of a Travelling Ecologist, 6

On monitoring

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Monitoring. We, ecologists, hear the word nearly every day. From the most unexpected corners this word springs out, much used and abused. One one hand, it is often used by my peers to justify their work, their project or even their existence as scientists. They claim to do useful work, because they monitor some phenomenon or another. This, goes the argument, is essential for the continued survival of … generally, nothing less than humankind. On the other hand, the mention of monitoring is also used by developers to get their way and push ahead freely, claiming that "monitoring" will indicate if something goes wrong. They rarely mention that a realisation of a harm or "wrong" (as an outcome of monitoring) does not imply corrective action – but they know it only too well. But let us return to ourselves, scientists.

Talking to people studying a group of living organisms, be those small or large, plant or animal or something else, living in the air, water or mud, they call they study group "indicators". I have yet to talk to a colleague who would proudly declare that her group is not a useful, or even excellent "indicator group". On prompting, they even list a number of assumed reasons why this be so. They are often right.

For everything is an indicator. Literally. This is the little-known but very true universal principle of indication, proposed by the Hungarian ecologist Pál Juhász-Nagy (1932 – 1994): every organism is an indicator. By their presence, they indicate that the conditions necessary for their survival are present in the habitat where they are encountered. Juhasz-Nagy, however, went further. He realised (Juhász-Nagy, 1986) that one cannot speak about indication without clarifying the relevant elements. The first is: what does the indicator indicate? What is to be indicated? What is the indicandum? And here is where trouble starts – people talking about the phenomenon of indication often fail to identify this indicandum. Once this is done, we have the indicandum (the phenomenon), and the indicator (the organism that will give the signal). Further, it helps if we can identify the index – the parameter by which the indicandum – the phenomenon to indicate – is measured. So what do we want to detect, by which parameter, measured on which organism? It is clear and simple – yet all too often not specified. If any one of these remains unspecified, there is confusion. The theoretical framework suggested by Juhász-Nagy has much to recommend to increase the clarity and usefulness of indication.

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Of course, the story does not stop here. Monitoring is a game of simplification. It is evident that everything cannot be measured. But – how far can we go? If we want to detect the reaction of natural enemies to a new chemical – how many types or species do we have to examine to indicate the general reaction of natural enemies? And how many parameters do we have to measure? To what degree is the reaction given by an indicator a signal of wider conditions? Or what can we indicate with what? What indicandum is indicated by the indicator? At what level does our indication become unreliable?

A further problem is that monitoring usually has to be extensive – yet we usually study small areas – intensively. I heard from the influential British ecologist John Lawton (now Sir John), that our ecological knowledge originates from an average area smaller than a room. It is no wonder then that we have enormous difficulties in scaling up to large scales results obtained at such a small scale. Many ecologists still feel uncomfortable with the notion of collecting data from a wider spatial scale, but at cruder resolution – they would not give up the detail. This may lead to the often-lamented "impracticality" of the solutions suggested by scientists to the problem of monitoring.

Our technical tools are now very sophisticated to enable us to collect large amounts of data from very wide areas – interpreting them is still a challenge. Clearly and explicitly describing the aims of any monitoring program would be a large step forward. This is often mentioned in methodological advaic eon monitoring (e. g. Sutherland, 2006). What is usually not mentioned is that the precise identification of the triad indicandum – indicator – index is a useful, even necessary first step.

Take, for example, the monitoring of transgenic crops after field release. Arguably there may be unforeseen effects emerging, for example, from the difficulty of predicting the effects of large-scale cultivation, when the assessment of impact had to be based on spatially and temporally limited pre-release experiments. This is the reason that such monitoring is a legal requirement in the European Community. However, there is a catch: there exist no standards. Developers of transgenic plants are therefore at liberty when it comes to describing their intended monitoring plans for a to-be-released transgenic plant. The suggested "monitoring schemes" are often rather ridiculous, even if they are sometimes supported by scientist who are – judging from the proposals-unprepared for the task of designing a proper monitoring procedure. Even naming the indicandum seems a too-difficult problem. Yet we need minimum standards that we can and should follow when monitoring, so that we have some confidence that our results will signal on time if some unexpected change happens. Only then might we be able to take action. To fill this formidable gap is the aim of a current EC-supported project, AMIGA. The AMIGA project (www. amigaproject. eu) is testing some commonly used or suggested monitoring methods in various European countries, following the same protocol, and the same cultivars. By doing this, we hope to come up with suitable suggestions and methods of quality control.

I do not talk about effects that are necessarily negative. A very extensive and detailed monitoring program has been (and still is) run by the Institute of Plant Protection of the Chinese Academy of Agricultural Sciences in several provinces of China. The aim was/is to detect the appearance of possible development of resistance against the transgenic Bt-cotton in its main pest, the cotton bollworm (*Helicoverpa armigera*). There has also been a general ecological surveillance of pest and natural enemy numbers. By monitoring a large area, it was possible to detect that the key pest is decreasing not only in cotton but in other crops (Wu *et al.*, 2008), and that another group, mirids (seed bugs) are increasing, also on a landscape scale (Lu *et al.*, 2011). These effects can be explained – yet they were surprises. It would be a

mistake to declare that this is not news – as the saying goes, "hindsight is an exact science". These – retrospectively understandable – relationships were not considered before. The Chinese monitoring program is a good example that the effects of transgenic crops will be multiple: some positive, while others negative. It is also a good example that scale matters, and we cannot always predict large-scale effects from small-scale experiments. So the EU decision of obligatory monitoring is eminently sensible.

For GM environmental monitoring, the phenomenon to be indicated, the indicandum, can be "proper ecological functioning" – but what is the index? What is the appropriate parameter that can indicate this indicandum? And once these are established, what can best indicate this? What is the simplest, fastest, cheapest indicator procedure that still gives results of acceptable precision? For indication is always a game of simplification. We can simplify the indicandum itself: let us say, for the sake of argument, that it is the (continued) functioning of biological control by natural enemies. What is the appropriate indicator here and what is the best index, to obtain the most reliable indication? Is any natural enemy group equally suitable? If we follow changes in their density, is this a good index? If so, what level of changes would provide the desired reliability of indication? This much depends on the precise definition of the indicandum/indicator relationship. The answer is not trivial, and is worth pondering carefully and long. It is rarely done. But it should be done, and more frequently.

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