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Reflections on a unique landscape

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Thanks so much to the New Zealand Grassland Association. I am sincerely humbled to have the opportunity to say a few words on my thinking looking back at an almost continuous time as a grassland entomologist. This was, however, interspersed with sometimes unwelcomed bouts of management. Immediately, I must acknowledge my primary mentors the late Peter Pottinger, Rod East, Bill Kain and John Lancashire.

Initially as a junior scientist I followed the MAF pathway rather than the DSIR route; some said that I secretly wanted to be in the DSIR which was only true sometimes. MAF and DSIR were the old Government Departments that were, amongst other things, charged with doing the nation's pasture research. There was a lot of rivalry between them. Anyway, it solved itself with the 1990s science reforms because the Government science departments got melted down and turned into the corporatised Crown Research Institutes (CRIs). Many of us landed in AgResearch. Irrespective of such goings-on, the 1970s biological and ecological grounding I got at Otago University and Lincoln College, and the professional support via the then New Zealand science system, I believe was second-to-none.

Rather than subject you to a year-by-year plod through what I have done in my 40 odd years, I thought that I could discuss a couple of perspectives that I have developed about the ecology of our grassland ecosystems. I will also give you a glimpse of what I think of the current science environment as it relates to pastoral agriculture.

A couple of things though. At first I didn't really want to work on pastures; cherries, kiwifruit, grapes and things like that looked far more attractive. But believe me, I subsequently readily wrapped myself in pasture research and will never regret it. The stuff I heard yesterday on farming hard hill-country was truly fascinating.

A well-meaning and close friend suggested that this talk could be some kind of valedictory. Maybe he knows something I don't, but irrespective of paid employment, I would never let go of the interest I have in the grasslands that I have been lucky enough to have worked in during my career.

New Zealand grasslands as an ecosystem

I would like to describe to you some of my current observations about the grasslands that we are variously associated with. I must admit that this relates mostly to rolling hill-country and the Canterbury Plains.

I must confess that the first 15 years of my entomological career involved trying to kill things. My colleagues and I were frequently described as 'nozzle-heads' and our science was described as 'squirt-and-count'. This is probably fair. Many of us got scooped up during the post-DDT panic when all kinds of pests, but most notably grass grub and some exotic species, made a huge resurgence in the absence of many enemies that had been repeatedly blasted by blanket applications of various organochlorines. Around this time DDT had been banned mainly because it persisted in the environment and messed up all kinds of ecological networks including making bird egg-shells too thin. Part of the job for us then was to find non-persistent alternatives to DDT. This turned out to be quite frightening as it often involved testing sometimes the contents of unlabelled aluminium bottles. These products were often acutely toxic organophosphates, supplied by pesticide companies along with free lunches. This work was pretty much all about replicated rates of application in randomised block designs to assess pest mortality and often accidental worm kills. In truth, for broad-acre agriculture this approach was simply not going to work. The lack of persistence, the cost and the acute toxicity of these new materials were never going to substitute for days when DDT was flung around mixed with superphosphate. Indeed, as we heard yesterday we are still struggling with grass grub as an aftermath.

A way forward over such a large landscape was going to have to be biological control and plant resistance. An obvious corollary here was that we needed to understand the biology and seasonality of the target pests. This led to an era of intensive and I think quite brilliant work on pasture pest population dynamics by Rod East and Bill Kain. This has remained a cornerstone of our pest management approaches ever since. For biological control, this has meant the development and use of pathogen-based biopesticides and classical biological control whereby natural enemies are released into the pasture ecosystems specifically to knock out targeted pests.

I cannot possibly traverse in any detail the years of work in these areas. Suffice to say that 30 years ago

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some colleagues and I got thoroughly involved in the classical biological control part of the equation. Actually it was also about this time that we entered into and have remained in a tailspin of having to bid for decreasing amounts of money for increasingly trivial work. It all began with user-pays. I will briefly refer to this again a little later.

From a more sunny perspective, the classical biological control story of invasive pasture weevil pests in New Zealand has been extraordinary. The exotic and highly-invasive weevils we worked on were lucerne weevil, clover root weevil and Argentine stem weevil. I will take a bit of time to explain what happened and why. I believe that this has implications for how we should now see our pasture ecosystems, which, thanks to our highly effective farmers in partnership with industry and research, remain second-to-none.

There is no doubt that New Zealand's improved pasturelands are wide open to invasive exotic pest species. Insects of little more than taxonomic interest in their native ranges reach colossal densities in New Zealand. I do not need to describe the damage they do. However, there is something else. There are 100 other species in the same genus as the clover root weevil lurking in Europe and 117 in the same genus as Argentine stem weevil in temperate South America. Should any one of these get in, it is likely to rip across our pastoral landscape. The threat is indeed severe. The need for biosecurity is obvious. Anyway, it has long been presumed, but rarely enunciated, that the proneness of our pastures to such invasion is because there is little biotic resistance to these species, coupled with the prospect of wall-to-wall supplies of high-quality, host forage plants. Tellingly, this proneness to invasion is in complete contrast to the fate of Argentine stem weevil in the grasslands of Europe. The pest has indeed been intercepted a number times, but has never established. The reason for this must be the huge biotic resistance provided by a miasma of predators, parasites, competing species and full ecological niches. The weevil simply can't establish.

Anyway we did the obvious thing. In response to our trio of invasive weevils we and others went back to the foreign native ranges of these pest species and searched for their most obvious natural enemies. On three out of three occasions, these turned out to be tiny parasitic wasps all of which are in the genus *Microctonus* which apparently means 'little murderer'. These wasps lay an egg in the weevil's body-cavity and the ensuing larval stages kill by devouring its innards. Usually the levels of parasitism we found in the native range collection sites were often less than 10%; amazingly, here in New Zealand, the levels on every occasion shot up to 90%. Thus, biological control was achieved on three consecutive occasions. Based on international biocontrol statistics, the chance of this trifecta was one in a thousand.

Had we been brilliant; what was going on? In hindsight the answer is obvious, it wasn't about us. The control agents, in the same way as the pests, had similarly encountered no biotic resistance so they also literally took off. Thus the pest populations and parasitism rates have been at levels that had probably never occurred in evolutionary history and this happened three times. We entomologists could indeed hold our heads up with those serious endophyte people, one of whom I trust was joking, when he described our control agents as 'biological curiosities'. However, in a way he was right. Two of the parasitoids, the one against the Argentine stem weevil and the other against the clover root weevil, reproduce asexually resulting in lines of identical daughters. This characteristic is thought to aid in the establishment these wasps.

This should be the end of the story but actually it isn't. In the last 5 years it has become evident that the Argentine stem weevil biological control agent has stopped working. Recent research has indicated that this is possibly though rapid evolution resulting from the high selection pressure exerted by the parasitoid on the weevil. Significantly here, the parasitoid had been not been able to evolve because of its clonal reproduction – whereas the weevil could have evolved. This is sometimes described 'as an unequal evolutionary arms-race'. Indeed, since the wasp's introduction in the early 1990s the selection pressure has been about at the same level as that exerted by continuous use of synthetic pesticides. Thus perhaps, resistance should not be unexpected, although it has not been found anywhere else in the world.

We are working on this observation now and in doing so have linked it to ecological theories relating to the lack of biodiversity in our pastures, the ecology of which we believe is like nowhere else.

At this stage I get into quite earnest discussions about biodiversity and this may affect invasive species. There are many who say there is indeed biodiversity in our pastures, so what am I on about? However, what I am referring to is functional biodiversity as it pertains to exotic invasive pest species. I am similarly assured that there are loads of natural enemies lurking in New Zealand's headlands and forest remnants. However, I am not sure. Even if they are there, they seem to stay where they are. This is in complete contrast to pastures in the northern hemisphere where grassland areas may be viewed as holes in what is basically a woodland landscape. In such a different setting, natural enemies range across all of the ecosystems as if they are one.

Not so in New Zealand; here things are completely different. In effect, as Simon Upton has put it to me, we have a huge clash of ecosystems across our landscape.

Of course we have a highly evolved, typically species-rich indigenous ecosystem that has developed over the last 80 million years. However, right up against this, we have our pastures which, in effect, are incomplete transplants of a few of Europe's grassland species; in short they are in no way evolved ecosystems. Thus two adjacent ecosystems are alien to each other and research has shown that in general at least, the insect species in them rarely if ever interact or cross-over.

So why has the resistance to the parasitoid occurred? In short, in New Zealand, in our species-sparse pastures there has been nothing to deflect the parasitoids from singularly attacking their hosts. This is quite unlike what goes on in the parasitoids' native ecosystem where its ability to parasitise is compromised by the wide range of interacting species, including its own slew of natural enemies and niche competitors. Add to this the 'unequal evolutionary arms race' thing mentioned above and it starts to make sense.

To counter these circumstances and bring about full ecosystem function, there are well-intended efforts to increase the diversity within our pastures and surrounds to create a sort of doppelganger landscape of the Palearctic grassland ecosystems. We can indeed introduce existing diversity within and around our pastures and the scenery can certainly be reminiscent of that the northern hemisphere. Also, such planting will bring native vertebrate species closer to our pastures and of course, aesthetically, it is pleasing to see them nearby. It also of course, helps honey production. However, I don't believe these plantings will do much in the way of pasture pest suppression. From a natural enemy point of view, the diversity will probably remain functionally inept when it comes to suppression of invasive exotic pests. There will simply not be the enormous range of interacting species that keep pests down as occurs in their native ranges. Yes, obviously we could bring in some additional aggressive exotic arthropod natural enemies to more closely approximate what is found in the evolved ecosystems, but then there would be numerous and colossal non-target impacts including the competitive displacement of native species. The ecological disruption would be severe and permanent.

So what to do? Firstly, on the upside, the simplicity of our pastures does indeed offer the potential for exceptionally effective biocontrol and in many ways works in our favour. We have already demonstrated that. But will it last? Perhaps not. Thus we need to treat successful biocontrol systems as rare resources that we need to understand and hopefully preserve. With this there is the opportunity to use new DNA-based technologies to understand more about how rapid evolution in pests can occur in our pastures, how it may be recognised early and perhaps how it may be averted. Also, and I think very promisingly, it is possible that DNA technologies can be used to develop marker-assisted selection for virulent parasitoids to systematically counter any evolved losses of efficacy.

Here I would like to emphasise that the ideas I have been discussing may well be heretical and wrong, but I believe that they provide a framework for future consideration including the role of biodiversity in our pastures. In short we are not like northwest Europe and many of the presumed lessons we have learned from there re pasture pest management and so on may not actually fit with New Zealand. We need to explore this and above all learn a lot more about the ecology of pasture production. The weevil work is a classic example of why we need to this. Who knows, the same could well also occur with the biocontrol of clover root weevil which has a biology similar to that of Argentine stem weevil.

The funding imbroglio

I have just mentioned that we need to do more on pasture ecology *per se*. Chance would be a fine thing.

I do not want to end on a sour note, but I have to say something about the science status quo. I believe that I have been very lucky to have been employed at a time when I and others were able to develop the sort of perspectives I have just traversed. There remains an inescapable need to do long-term research. Almost always this is where the truly serious progress of breakthroughs occur. For example, look at the endophyte work. The current fragmented short-term system now absolutely precludes this and strangely, it is now somehow argued that this is our sector's fault.

With regard to our magnificent pastoral landscapes and their huge contribution to the country's economy, there was a time when these were well-protected and informed by public-good science. There were government and quasi-government agencies like rabbit boards, soil conservators, hydrologists, forest services, weed authorities, farm advisers and numerous others. These were largely about protecting landscapes, national potential for production and above all, the common good. This has long since been swept away. I therefore admire the ongoing efforts of those who persist in such activities. This was well covered yesterday in Mel Poulton's speech.

Some years ago mothership AgResearch and the land-based universities *de facto*, acquired the responsibility for taking care of many of these incontrovertible requirements. This has been at a time of free-falling budgets, the remnants of which now fund little more than technology transfer, in addition to that already covered by industry levies. Amongst all of this, there has been a view that farmers must instead also cover the costs of heartland science and if they don't, then

it is presumed that they are not interested, so why should the government fund them? This sort of attitude has occurred at a time when it is abundantly clear that this type of research need lies well beyond immediate means of commercial farming. Yet bizarrely, the funding collapse continues at a time of surging national concern about the state of the environment.

Finally with this, there is anguish about recruiting pasture researchers. Like my own area this sort of work requires long and specialist training. Consequently there must be some kind of understanding that after training and given adequate ongoing effort, then employment is a reasonable prospect.

So many have recently learned to their own cost that now this is not the case.

I am sorry, I really don't get it. However, there has to be a silver-lining for you young springy scholars. The new government, if suitably prompted by us, may indeed react positively, especially as a large number of people are likely to retire in the next 5 years and public awareness continues to grow. The country with its huge dependence on agriculture simply cannot do without research.

Conclusion

That resistance to a classical biological control agent has probably occurred in New Zealand for the first time, I think probably reflects the uniqueness of our pasturelands. As discussed, this uniqueness has both good and bad features for pastoral agriculture. Irrespective, a facet I have always appreciated is that the New Zealand grasslands continues to offer the opportunity to develop ecological theory quite unlike that of anywhere else.

I hope that this contribution has given a bit of a sense of that.

Notwithstanding the frustrating funding environment I have just referred to, it has been a fantastic experience working in New Zealand's pastoral ecosystems. Looking back I simply cannot imagine having done anything else.

As far as I know these words are not valedictory and as such, I very much look forward to continuing to work (paid or otherwise) in this country's grasslands.

Again I am grateful and honoured to have the chance to put these views to you. Thank you all.