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The entomological thread of federal agricultural research: Saskatoon 1918-2014

Introduction

Entomology has been a feature of federal agricultural research in Saskatchewan for nearly 100 years. Thanks to the Riegert family, the University of Saskatchewan Archives has a very comprehensive collection of entomological heritage publications, notes and photographs for western Canada that were compiled by Paul Riegert. I was aware of many of Paul's historical publications over the years, but it was awe-inspiring to see the extent of his records and files. A complete listing of the university holdings of Paul's archives can be found on the Entomological Society of Saskatchewan website.

After several visits to the university archives, I came to the realization that, at best, I could update just one 'thread' of the entomological fabric that Paul had so thoroughly assembled over the years. The publication ***A History of the Dominion Entomological Laboratory in Saskatoon, SK*** (Riegert 1995) caught my attention when I realized that I had actually met several of the original staff members of the Dominion Entomological Laboratory (DEL) during my tenure as an undergraduate student working at the Canada Agriculture Research Station (CARS) in the 1970s. I was captivated. Hence, I made the decision to begin my presentation with the DEL – Saskatoon, and to follow the entomological thread of agricultural research through CARS (where my career began) and over to the Saskatoon Research Centre (SRC), currently a research facility of the Science and Technology Branch of Agriculture and Agri-Food Canada.

Dominion Entomological Laboratory

The development of federal government agricultural research began with the establishment of select Experimental Farms under the direction of William Saunders in 1885. By the early 1900s, the demand for entomological expertise within the Prairie Ecozone increased with expanded settlement, in part due to the large-scale disturbance of native prairie soils that influenced the pest status of some indigenous insect populations. In 1913, Norman Criddle was appointed as the entomological officer in Manitoba and Edgar Strickland in Alberta. But it wasn't until 1918 that Dr Alfred Cameron received a joint appointment between the Government of Canada and the University of Saskatchewan, and the Dominion Entomological Laboratory– Saskatoon was founded (Harding 1986). The government did not own any buildings on campus at the time, so the DEL was co-located at the University of Saskatchewan in the basement of the Field Husbandry Building.

Dr Cameron arrived in Saskatoon as the first Officer-in-Charge, with the intent of studying indigenous blackflies (*Simulium* spp.). However, a major grasshopper outbreak in the province demanded his attention and early DEL staff were immediately caught up in monitoring and controlling this major pest of field crops. Dr Cameron left the DEL to return to studying biting flies after only 2 years, and was replaced by Dr Kenneth King. It was Dr King who really

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established the DEL as a centre of excellence in insect ecology (Harding 1986). Although grasshoppers dominated for years as agriculture continued to expand, an array of insect pests surfaced including Hessian fly, bertha armyworm, wireworms and cutworms. As a result, the DEL increased its staff of officers to seven by the early 1930s. Research activities at the DEL were severely disrupted in the early 1940s due to the Second World War. However, the unit was re-invigorated soon after and had a staff of 25 (including officers and technical staff) by 1950. The range of entomological expertise had also expanded and included taxonomy, biology, life history studies, and control options. In addition to grasshoppers, cutworms and wireworms, wheat stem sawfly had become a major issue as well.

The major issues addressed by the newly-established DEL related to pest control, insect ecology, monitoring and forecasting. Control methods were very limited. As a result, early researchers had a mandate to develop control options – cultural, poison baits, etc. For example, Dr Arni Arnason utilized his resources on hand and designed a control method using bags of arsenic powder and horses to control bertha armyworm in 1928 (Fig. 1).

Figure 1 - “Horse and Pole Duster”. Dr Arni Arnason using arsenic powder to control bertha armyworm in 1928 (Harding 1986).

Since Paul had already thoroughly reviewed early pest control tactics in “***From Arsenic to DDT***” (Riegert 1968), I decided to focus on the other major initiatives, namely insect ecology, monitoring and forecasting for this presentation. Given the urgency of the grasshopper threats to early agriculture, it seemed fitting to begin with grasshoppers (*Melanoplus* spp.; *Camnula pellucida*) as my example of insect monitoring and forecasting during the DEL era. The earliest reference to a grasshopper forecast map was published in 1920 (Fig. 2).

The DEL preceded the era of blogs and Twitter, but technology transfer was taken seriously using billboards and posters that were displayed in town halls and post offices (Fig. 3). With catchy logos such as “***Fields Cannot Successfully Produce Both Grain and Grasshoppers”*** and eye-catching images, the posters enlisted wide farmer support for controlling grasshoppers using four main tactics: (i) Do not seed fields infested with grasshopper eggs; (ii) Plant guard and trap strips to attract the grasshoppers and then control the strips; (iii) Control grasshoppers in roadsides and pastures; and (iv) Repeat the control applications every 4-7 days….with a reminder: “***Don’t let your neighbour down***”.

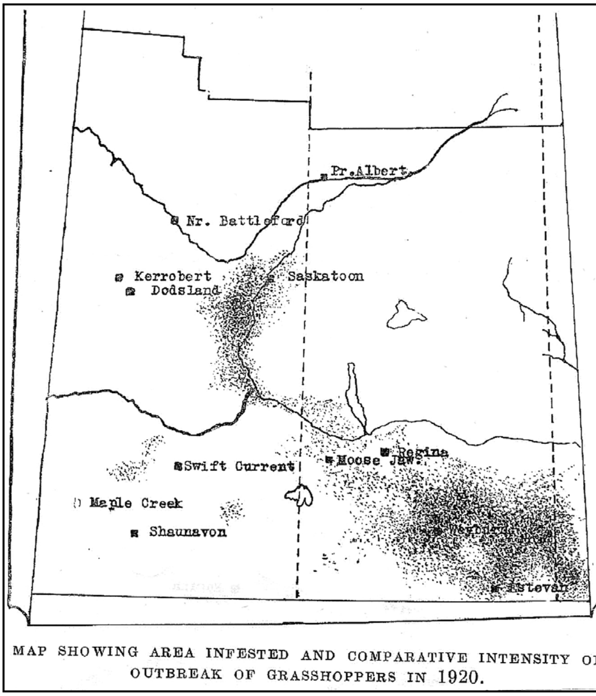

Figure 2. Map showing survey locations of grasshopper distribution in Saskatchewan in 1920 (University of Saskatchewan Archives).

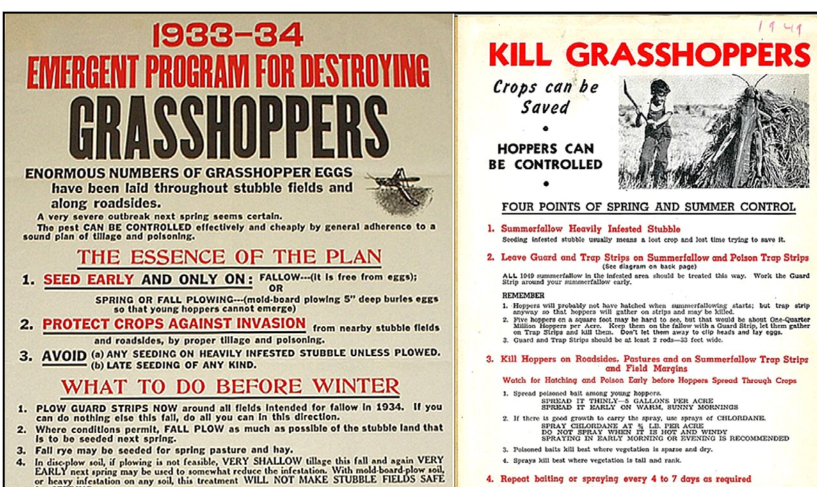

Figure 3. Posters advocating grasshopper population control in Saskatchewan in 1933 and 1949 (AAFC-Saskatoon Research Centre).

In support of the annual grasshopper campaigns, contoured forecast maps were meticulously hand drawn up until 1980 by data analysts with drafting expertise (Fig. 4). Following the retirement of the data analysts/sketch artists, population data were averaged over rural municipalities for the next 10 years or so until GIS mapping tools became readily available in the 1990s. In summary, field survey data of Saskatchewan grasshopper populations date back to 1920, and are continued today, making it a world class record of annual insect population distribution and density.

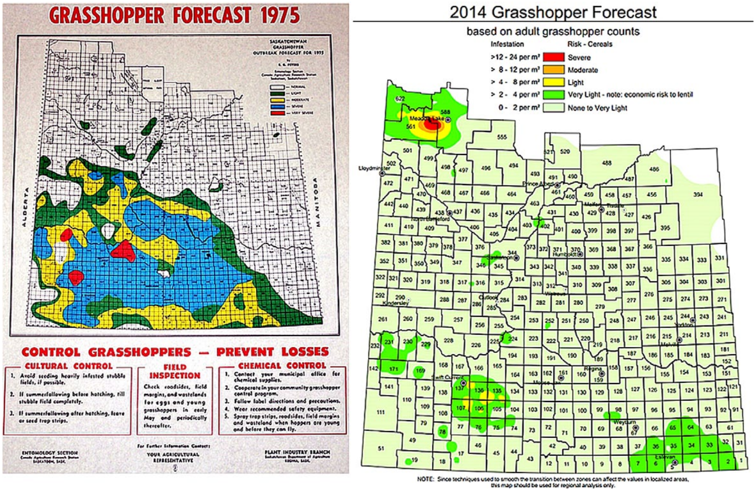

Figure 4. Grasshopper forecast maps for Saskatchewan – 1937 (left) (AAFC-Saskatoon Research Centre) and 2014 (right) (Saskatchewan Ministry of Agriculture)

Canada Agriculture Research Station

A new government laboratory was constructed on the University of Saskatchewan campus in the mid-1950s, allowing for a consolidation of the federal agriculture 'Science Service' staff. In 1959, the Dominion Laboratories of Entomology, Plant Pathology and Forage Crops were combined forming the new Canada Agriculture Research Station (CARS). Largely due to pressure from lead farm groups, entomology continued to flourish in Saskatoon (Anstey 1986). By the 1960s, CARS had a staff of 20 entomologists with a broad range of scientific expertise. They included:

- Grasshoppers: Howard MacDonald – chemical control; Paul Riegert and Roy Pickford – ecology; Robert Randell – population demography
- Forage crop insects: Harold McMahon and Harvey Craig – control
- Rapeseed insects: Lloyd Putnam – control; Larry Burgess – ecology
- Medical entomology: John McClintock and Raymond Bellamy – Western Equine Encephalitis.
- Biting flies: Hartley Fredeen – control
- Vegetable insects: Woody Stewart – control
- Wireworms: Robert Burrage and John Doane – ecology
- Physiology: Norman Church – development; Al Ewen – reproduction; Richard Davis – nutrition
- Pesticides: Jadu Saha – chemistry; Kenneth MacKinlay – toxicology

Some of the staff were also involved in international and national projects. For example, Hartley Fredeen was seconded to EXPO-67 in Montreal for three years (1965-67) to develop and manage a comprehensive insect control program to mitigate insect problems during EXPO.

However, by the early 1980s, the IPM research team was down to 11 entomologists. Fortunately for producers, this core group was of sufficient size to begin to address the devastating outbreak of a new invasive alien species in 1983, wheat midge (*Sitodiplosis mosellana*). I decided to use wheat midge, as my second example, to continue the discussion on insect monitoring and forecasting. John Doane laid the groundwork for a unique monitoring and forecasting tool that tracked both the pest and its biological control agent, *Macroglenes penetrans*.

Monitoring of overwintering populations is conducted in fall by taking soil cores to a depth of 15 cm. The cores are processed by wet sieving as described by Doane *et al*. (1987), and larval cocoons and larvae counted. All larvae are then dissected to determine if they are parasitized. This unique monitoring tool allows researchers to quantify the positive impact of biological control in managing wheat midge below economic threshold, as well as determining wheat midge population distribution and density.

Figure 5 depicts wheat midge population distribution and density in 1997. On the left is a distribution and density map of total number of midge larvae collected in soil samples. On the right is the same population, but only the viable midge data are presented; the parasitized larvae have been excluded. One can very easily see the positive impact of the parasitoid in reducing risk for the subsequent growing season. The decrease in red, blue and yellow areas reflects the reduction of midge populations in the province to below the economic threshold of 600 midge/ m^2.

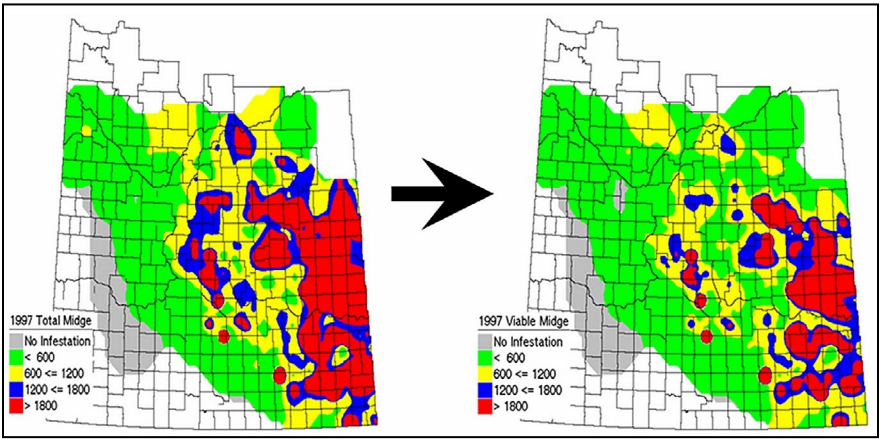

Figure 5. Contoured maps of the distribution and density (numbers/m^2) of wheat midge populations in Saskatchewan in 1997, based on larval cocoon counts (Olfert *et al*. 2009).

Using these data, Olfert *et al.* (2003) were able to estimate that the total savings in pesticide costs, due to biological control of wheat midge, were about $248.3 million between 1991 and 2001. Average rates of parasitism in the study ranged from a low of 25% in 1996 to a high of 44% in 2001. The severe outbreak during the mid-1990's and the subsequent insecticide campaign to control wheat midge resulted in an overall decrease in the average rates of parasitism but they quickly bounced back by 1998. This achievement can be directly attributed to the successful implementation of parasitoid conservation techniques and the fact that wheat producers in western

Canada have access to one of the most comprehensive management programs of any insect pest of field crops.

Saskatoon Research Centre

In the mid-1990s, the federal agriculture Research Branch was significantly downsized nationally. However, facilities at CARS were retrofitted and greatly expanded and the new facility was renamed the Saskatoon Research Centre (SRC). Effectively, the number of staff at SRC doubled. However, public-good research (e.g., entomology) became a low priority with the director at the time, who favoured research with commercial potential. For almost a decade, the staff in the Office of Intellectual Property at Saskatoon outnumbered the five remaining entomologists.

Due to similar declining entomology expertise at all federal centres within the Prairie Ecozone, there was a critical need to optimize resources in order to retain a presence in insect monitoring and forecasting. In response, the concept of a coordinated insect surveillance program took shape in the form of the Prairie Pest Monitoring Network (PPMN) in 1996. PPMN is not an official name, it’s more like a description of a collaborative and coordinated suite of activities (technology transfer and research) related to insect pests of field crops and their natural enemies. Team members of the PPMN include provincial government entomologists, industry agronomists, university entomologists and federal government entomologists. Funding for the team and its activities comes from crop commodity organizations, industry and governments.

The benefits accruing to agricultural science from the activities of the PPMN are significant. Insect ecologists have access to approximately 5000 insect population abundance/distribution data points annually and hourly weather data from 400 weather stations (Fig. 6).

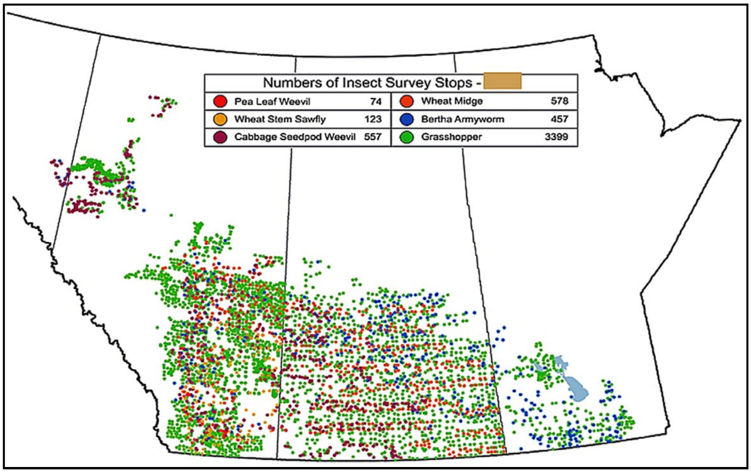

Figure 6. Example of GPS locations of major insect pest population survey data in the Prairie Ecozone in 2014 (AAFC-Saskatoon Research Centre).

In addition to insect population data, wind trajectory data from Environment Canada are downloaded daily during the growing season for 50 sentinel sites in Canada and 20 in the USA and Mexico. Air parcels capable of carrying insect pests reflect the potential for migratory pest movement (Hopkinson and Soroka 2010). Current insect targets of the wind trajectory analyses

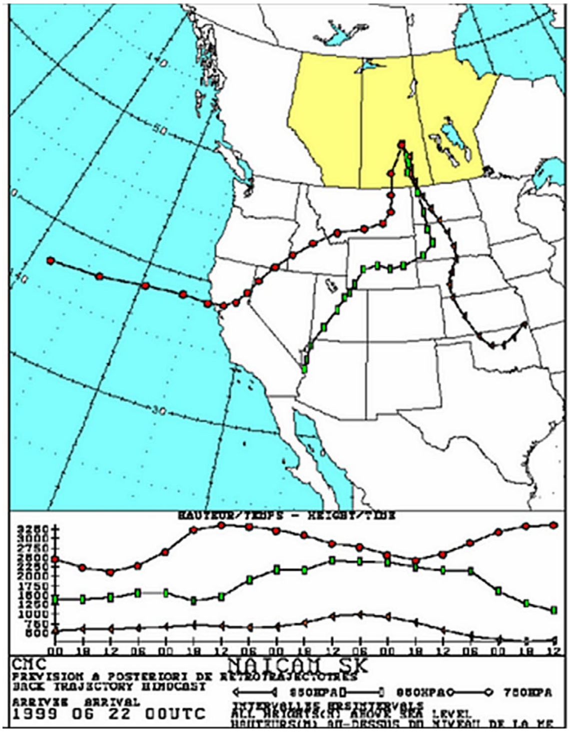

Figure 7. Example of wind current model output (back-trajectory) for Naicam, Saskatchewan, at 500m; 1500m and 2500m above ground. (AAFC-Saskatoon Research Centre).

include diamondback moth (*Plutella xylostella*) and aster yellow leafhopper (*Macrosteles quadrilineatus*). Trajectory analysis can be used to identify regions at risk on the prairies and, in turn, the analyses can provide input for the development of management strategies (Fig. 7).

In summary, all data generated by the PPMN are archived in a crop - insect - weather database. The database is a significant resource for identifying knowledge gaps and developing management tools. In addition, future impact assessments of climate change, new agronomic practices and new crops on pests and their natural enemies are within its scope.

The distribution and abundance of insects are correlated with climate, weather, agronomic practices and natural enemies As a result, the data can be used to develop and validate bioclimate models. By exploiting these ecological data sets, bioclimate simulation models can be used to identify broad patterns in population distribution and abundance (agricultural risk). I will illustrate this using as examples diamondback moth and grasshoppers.

Using the date of migratory diamondback moth adult arrival in Canada as a ‘bio-fix’ date in our bioclimate model, together with Long Term Normal temperature data, we can predict the potential number of generations (crop risk). Number of generations per year is one of the important factors that influence the pest status of diamondback moth. In western Canada, diamondback moth usually has three generations per growing season. The potential for crop yield loss increases with additional generations.

We have a bioclimate model for *M. sanguinipes* and have applied climate change scenarios to assess the potential impact of climate change on grasshopper ecology. Olfert et al. (2011) have shown that, compared to predicted range and distribution under current climate conditions, *M. sanguinipes* would have increased range and relative abundance under three commonly-used general circulation model scenarios in more northern regions of North America. Conversely, model output predicted that the range of this crop pest could contract in regions where climate conditions became limiting.

Conclusions

Entomology in this province had humble beginnings with the launch of the Dominion Entomological Laboratory in 1918. However, the demand for entomology expertise flourished as agriculture expanded with increased settlement of the Prairie Ecozone. The discipline peaked at the Canada Agriculture Research Station in the 1960s, with a scientific staff of 20 entomologists who had a broad range of expertise. In 2014, this number has been reduced to four scientific research positions at the Saskatoon Research Centre. However, insect ecology monitoring and forecasting are as strongly supported by farmers today as they were in 1918.

Given that the current cadre of entomological research staff at the Saskatoon Research Centre is nearing retirement, succession planning is critical in order to retain the entomological benefits that the agriculture industry has come to expect from ***DEL, CARS*** and now ***SRC*** for nearly 100 years. Entomology truly has been a major contributor to the success of agriculture in western Canada and, as such, is a most interesting heritage subject.

Acknowledgements

When first approached about the Heritage Lecture, my first thoughts were that these were awfully BIG shoes to fill! After all, Paul Riegert set a very high bar for entomological 'Heritage' in this province (and nationally). On a personal note, I recall that Paul had a short weekly segment on CBC radio years ago titled 'The Bug Doctor' where he would answer questions about insects. I don't know which came first, but I heard that he also had a personalized licence plate for his car: 'BUG DR'. In retrospect, it would have been equally appropriate for the plate on his car to have been 'HERITAGE DR'. I would like to thank Drs Julie Soroka and Cedric Gillott for comments on an earlier version of the manuscript. And I would like to acknowledge the tremendous assistance of the staff at the University of Saskatchewan Library Archives.

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