**AgriScience Program - Cluster Component**

**Project Number: ASC-04**

**Activity #2: Coordinated monitoring of field crop insect pests in the Prairie Ecosystem**

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# Activity Report Prepared for Prairie Oat Growers Association (POGA)

## 1. Background

Insect pest monitoring is a cornerstone of effective integrated pest management (IPM) programmes (Dent 2000) and is a component of biovigilance. To predict insect pest oubreaks and the impact of insect pests on field crop yields, it is necessary to monitor insect pests across the agricultural landscape of the Canadian Prairies. The Prairie Pest Monitoring Network was established over 20 years ago to provide a framework for collaboration and multidisciplinary research to better understand insect ecology as well as to record the changing distribution and relative abundance of insect pests and of their natural enemies. The Prairie Pest Monitoring Network is funded through the AgriScience Program as part of the Canadian Agricultural Partnership, a federal, provincial, territorial initiative, with support from Western Grains Research Foundation, Prairie Oat Growers Association, Alberta Wheat Commission, Saskatchewan Pulse Growers, Saskatchewan Canola Development Commission, Saskatchewan Wheat Development Commission, Manitoba Crop Alliance, Manitoba Canola Growers Association, and Manitoba Pulse and Soybean Growers.

In this activity, the Prairie Pest Monitoring Network will focus on: a) insect pest surveillance, forecasts, and alerts; b) enhancing existing tools used to survey and monitor insects; c) understanding the role of beneficial insects in pest management; and d) improving our knowledge of the biology, ecology, and impact of current and emerging insect pests. In our fourth year, the PPMN supported and conducted annual insect surveillance activities and collected data on beneficial insects. We produced Weekly Updates to provide information to agricultural stakeholders regarding insect phenology, meteorological data, and risk due to insects. Data collected in 2021 was added to the >20 year old database maintained by the Network. This historical dataset was used to develop a modelling protocol to estimate risk to wheat and canola crops from multiple insect pests (Manuscript accepted by *The Canadian Entomologist*). In March 2022, the annual Prairie Pest Monitoring Network Working Group Meeting was hosted by Meghan Vankosky and Jennifer Otani using a virtual format. At the meeting, Network collaborators discussed the 2021 insect distribution maps, reviewed insect pest issues in 2021, and discussed plans for monitoring in 2022.

**2. Objectives of the Prairie Pest Monitoring Network include:**

1. Implement a coordinated insect monitoring program, fostering existing interprovincial partnerships, for the Prairies Ecozone (including the BC Peace region), designed to keep the Canadian agriculture industry informed of the risks posed by insect pests.
2. Ensure timely response to new invasive pests with regulatory implications by immediately reporting finds to the Canadian Food Inspection Agency, as per the guidelines being established by the CFIA national strategy for plant and animal health.
3. Develop (or refine) and assess technologies and tools for identification, monitoring, tracking, and forecasting populations of insect pests of field crops using field surveillance and laboratory assays to record insect pest (and natural enemy) phenology, impact, and distribution to validate models used to predict threats, estimate insect impacts, and develop predictions to understand the impact of a changing climate on pest status.
4. Highlight the role of natural enemies and make recommendations to conserve natural enemies of field crop pests.
5. Develop technology transfer and communication tools to support the timely distribution of data collected by this project (i.e. weekly updates, annual risk and forecast maps with interpretive text, annual reports) to end-users, including agronomists and farmers.

**3. Methods**

***(i) Monitoring Protocols:*** The specific details of the monitoring protocols are posted on the Prairie Pest Monitoring Network website (https://prairiepest.ca). Updated versions of most protocols are now available; updated versions or new protocols for outstanding species will be posted in 2022. A short summary of the methods employed to monitor populations of key prairie insect pests is provided below:

**(a)** Grasshoppers (Acrididae). The number of adult grasshoppers per $m^2$ was recorded in fall shortly after harvest to determine species composition, density and distribution.

**(b)** Bertha armyworm (*Mamestra configurata*). Traps with pheromone lures were installed in canola fields (mid-June) to determine the time, distribution and density of adult moth flight.

**(c)** Wheat midge (*Sitodiplosis mosellana*). Wheat fields were sampled in fall using soil cores. The soil was washed and sieved to retrieve larval cocoons and free larvae. The larvae were dissected to determine the distribution, density and rates of parasitism of midge.

**(d)** Diamondback moth (*Plutella xylostella*). Sentinel sites were established in canola fields by installing pheromone traps to determine the time, distribution and density of moth migrations from USA. This activity complements the wind trajectory component.

**(e)** Cabbage seedpod weevil (*Ceutorhynchus obstrictus*). Weevil populations were surveyed using sweep nets (25 sweeps per field) to determine their distribution and density. The samples were brought back to the laboratory to be sorted and identified. All pest species of canola, and their natural enemies, found in the samples are also identified and recorded to assess multiple pest complexes.

**(f)** Pea Leaf Weevil (*Sitona lineatus*). Weevil densities were estimated by plant damage assessments performed from 2$^{nd}$ to 6$^{th}$ node stages during the late May and early June, at five locations within each field.

**(g)** Wheat stem sawfly (*Cephus cinctus*). Adults emerge in June and can usually be found in wheat fields until mid-July. Populations are assessed for annual distribution maps by a survey of wheat field margins late in the season and estimating the percentage of cut stems per $m^2$.

***(ii) Risk Warning Methods***:

**(a)** All data relating to insect populations were compiled on a weekly basis during the growing season. Spatial analysis systems were then utilized to summarize the distribution and density of the pest populations.

**(b)** Near real-time weather data, obtained from Environment and Climate Change Canada (ECCC) on a weekly basis, were used to implement degree-day models (i.e. accumulated heat units) and phenology models on a daily basis for pest species. Again, spatial analysis systems were then utilized to transform weather data into a format compatible with programs used to model insect population dynamics.

**(c)** Based on near real-time weather data, mathematical models for pest population establishment and growth were validated and implemented. Risk warnings were released at intervals appropriate to the pest - crop situation.

**(d)** Field sampling was conducted at sentinel sites for select species to validate forecasts. Pest and crop data were collected at approximately weekly intervals during June and July to enhance the accuracy of risk warnings.

**(e)** Model output on wind movement was obtained from ECCC and evaluated daily in relation to the potential for diamondback moth, leafhoppers and aphids originating from the southern USA and Mexico, and migrating to crop production regions of Canada.

**(f)** Bioclimate models were developed for native pests and for potential invasive species to assess the risk of successful establishment in the prairies and assess the potential for successful establishment of biological control agents.

## 4. Results in Year 4

Annual surveys of seven key pests were completed in 2021 using established protocols. The Prairie Pest Monitoring Network (PPMN) collected data from 5951 locations across the three prairie provinces. Of the locations, 3442 were surveyed for grasshoppers, 736 for bertha armyworm, 444 for cabbage seedpod weevil, 425 for pea leaf weevil, 634 for wheat midge, 187 for diamondback moth, and 83 for wheat stem sawfly (Figure 1). The number of sites sampled increased for most species between 2020 and 2021 as field activities resumed with fewer COVID-19 related interruptions in 2021. Pheromone traps were also deployed to approximately 40 sites in Saskatchewan to monitor for potential invasion of swede midge. No swede midge were detected in 2021. We continued to collaborate with Environment and Climate Change Canada (ECCC) in 2021 to use wind trajectories to predict the arrival of migratory pests (e.g., diamond back moth, leafhoppers, cereal rust) and information from these analyses were included in the Weekly Updates early in the growing season. A short summary of the survey results for seven pest species is provided below. Maps from this report are available online from https://prairiepest.ca. Maps in Figures 1-8 are courtesy of David Giffen, AAFC.

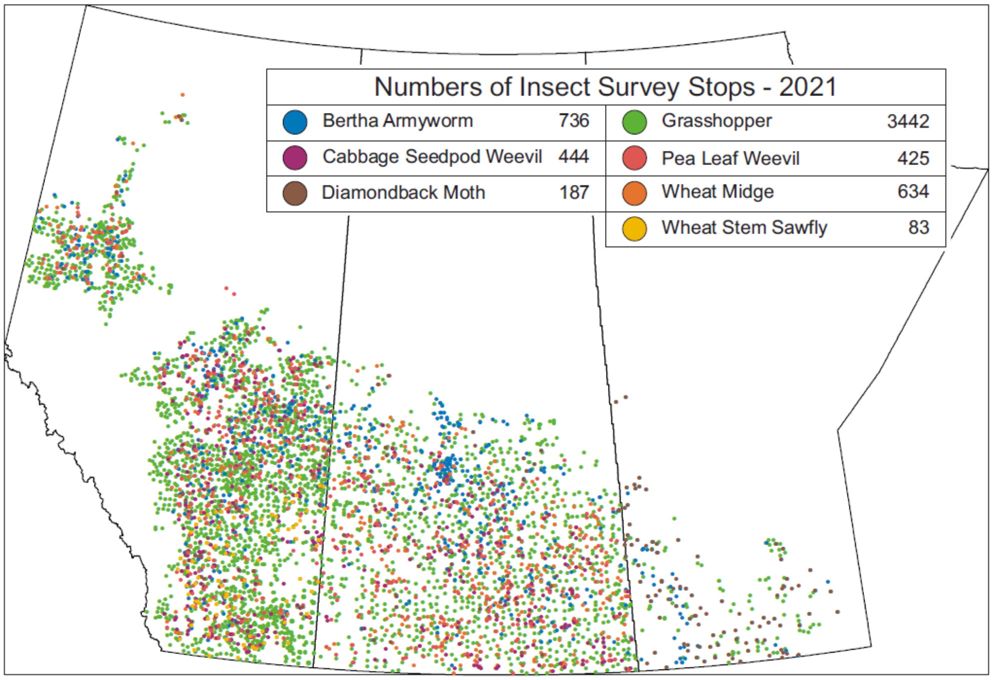


**Figure 1. The distribution of monitoring locations (n = 5,951) where insect distribution and relative abundance data was collected in 2021 (Map courtesy of David Giffen, AAFC).**

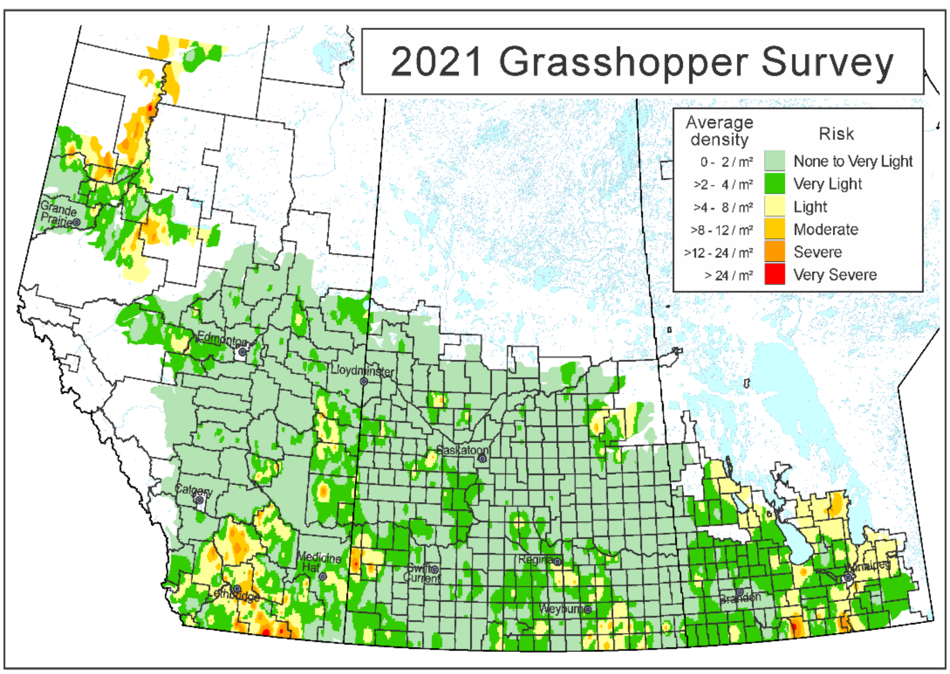


**Figure 2. Results of the 2021 grasshopper survey; risk in 2022 can be estimated based on fall survey results from 2021.**

***(i) Grasshoppers.*** Some areas of the prairies reported quite high grasshopper densities in summer 2021, with certain species (e.g., clearwing grasshopper) dominating localized outbreaks. Compared to the fall survey in 2020, the 2021 survey identified more locations grasshopper densities greater than 4 adults / $m^2$. Thus, if weather conditions remain warm and dry, there are more areas at risk of light, moderate, severe, and very severe grasshopper population densities in 2022 than there were forecast for 2021 (Figure 2). Farmers and agronomists should be prepared to scout for grasshoppers across the prairies in spring 2022.

***(ii) Wheat midge***. A survey of wheat fields was conducted in fall 2021 and the number of unparasitized wheat midge larval cocoons was used to estimate the risk of wheat midge infestation in 2022. The potential risk of wheat midge damage to crops in 2022 is expected to be quite low based on the fall survey results, as midge densities were quite low across the majority of the prairies (Figure 3). There were some isolated areas with higher densities of larval cocoons southeast of Edmonton and north of Saskatoon where risk could be greater in 2022 (Figure 3). Weather conditions in spring 2022 will also affect wheat midge risk, as wheat midge require periods of precipitation in the spring to trigger the completion of larval development.

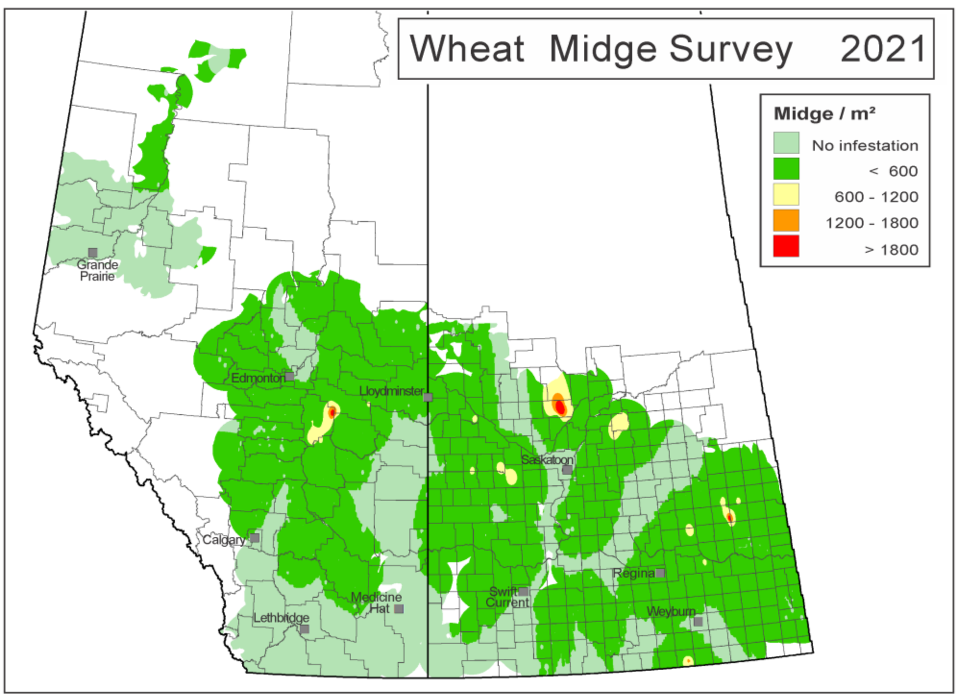


**Figure 3. The density of unparasitized wheat midge larval cocoons in soil samples taken in fall 2021.**

***(iii) Cabbage Seedpod Weevil***. The distribution of cabbage seedpod weevil in 2021 was largely unchanged from previous years (Figure 4). No cabbage seedpod weevils were detected in the Peace River Region in 2021. The presence of cabbage seedpod weevil in Manitoba was confirmed in 2017 but population densities are still quite low and a formal survey has not been instituted in Manitoba yet. Fewer fields than normal were sampled in 2021 in Saskatchewan and fields were sampled later than normal. Thus, densities may have been underestimated in the southwestern region of Saskatchewan in particular. The extent of the range of cabbage seedpod weevil with high numbers has been low since 2017 and this trend continued in 2021, although more fields with weevils in excess of 31 per 25 sweeps were sampled in 2021 than were sampled in 2020.

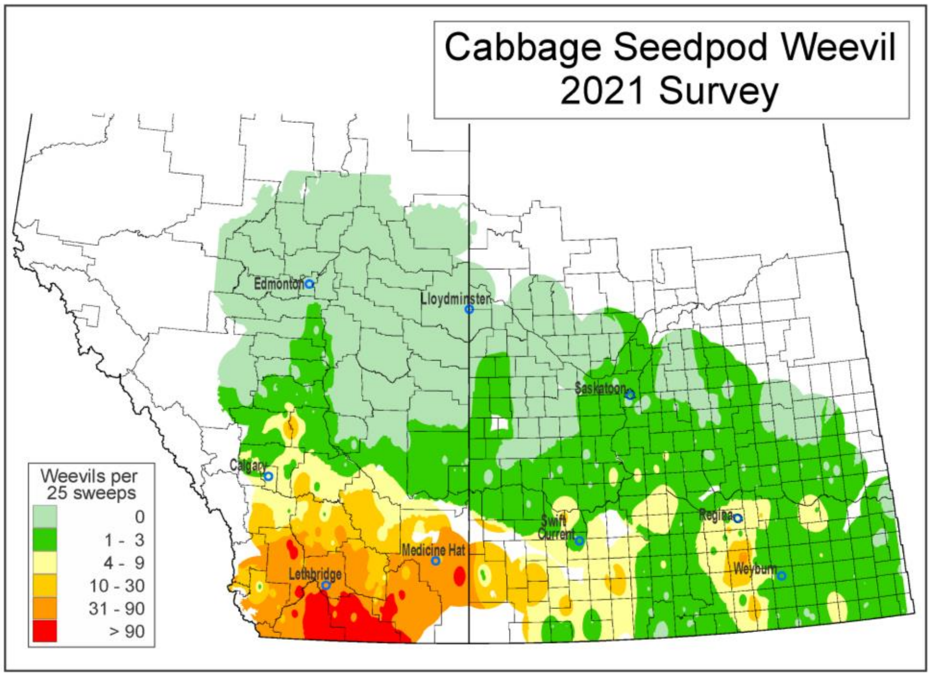


**Figure 4. Distribution and relative abundance of cabbage seedpod weevil in summer 2021.**

***(iv) Pea leaf weevil****.* In 2021, pea leaf weevil densities were low across most of Saskatchewan, although fields with one to nine notches per plant were sampled around Yorkton (Figure 5). In Alberta, there were more fields with one to 27 notches per plant sampled in 2021 than in 2020, especially around Lethbridge and Edmonton (Figure 5). Low densities of pea leaf weevil continue to be observed in the Peace River Region. In 2019, the presence of pea leaf weevil in Manitoba was confirmed; in 2020 and 2021, John Gavloski deployed pheromone traps in the Swan River Valley to monitor populations of this pest. Some fields had quite high trap counts. Dr. Gavloski is planning a small survey of fields for pea leaf weevil damage following the standardized PPMN protocol in 2022.

***(v) Wheat stem sawfly****.* Wheat stem sawfly populations have been consistently low in most of Alberta since 2011, but some parts of southern Alberta are currently experiencing a resurgence in wheat stem sawfly densities (Figure 6). Reports of wheat stem sawfly damage were also received from farmers in Saskatchewan in 2021, although no survey is conducted. In 2021, some fields sampled had significant stem cutting by larval sawflies. Fields with greater rates of parasitism were fields from the southernmost part of the province. Some fields monitored in 2019 and 2020 had quite high levels of parasitism. However, the parasitoid may have only been able to complete one generation in 2021 because plants matured earlier than normal in the drought conditions. Thus, parasitism in 2021 may have been lower than in previous years, which could increase the risk of wheat stem sawfly outbreaks in 2022, especially if hot, dry conditions persist.

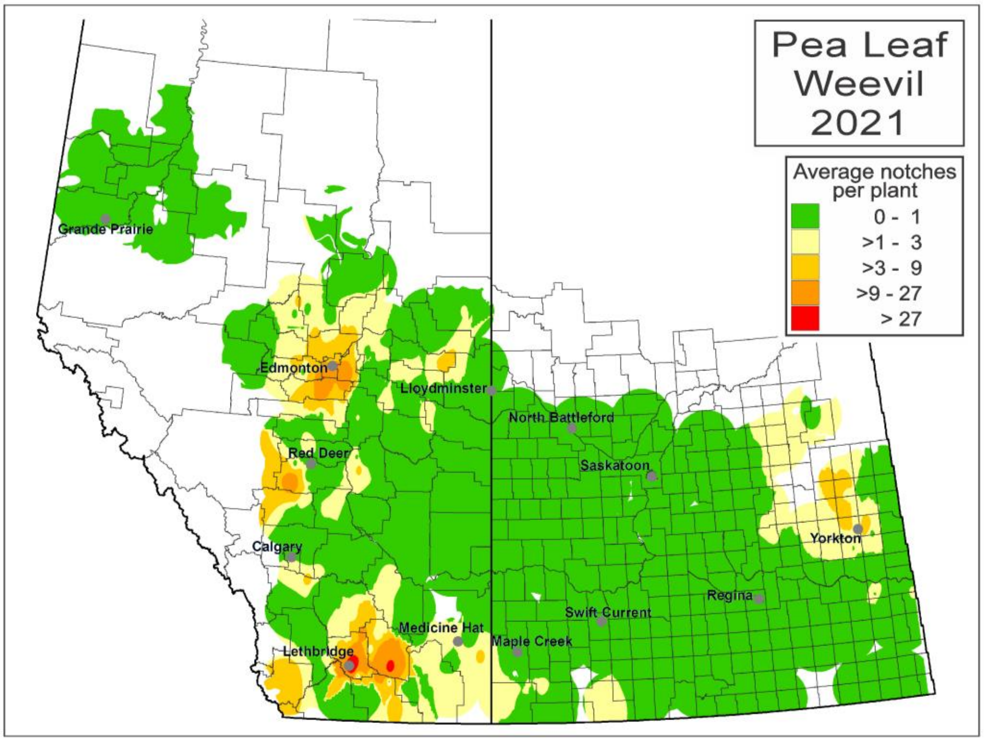


**Figure 5. The distribution of pea leaf weevil in Alberta and Saskatchewan in spring 2021.**

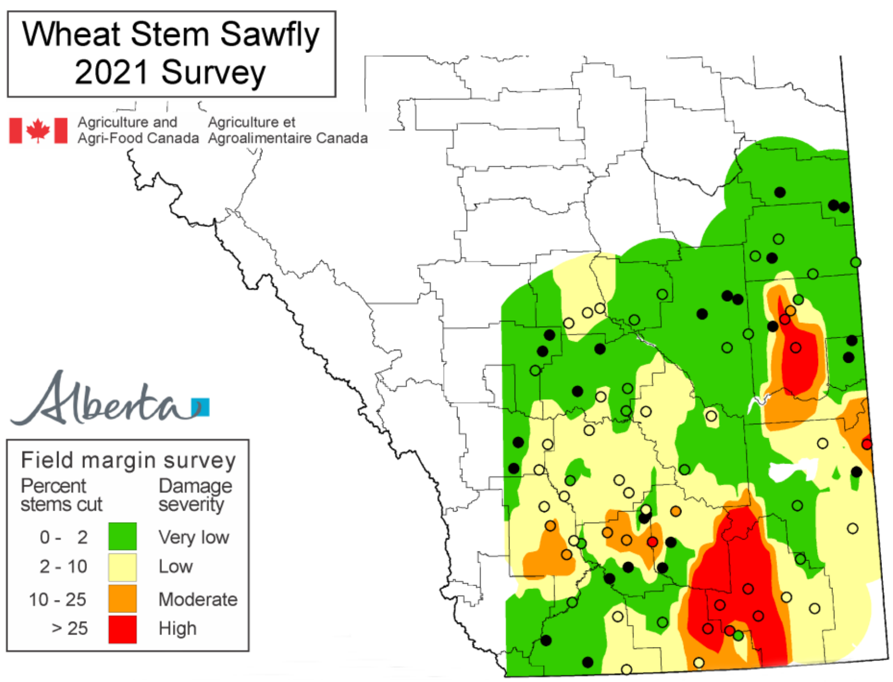


**Figure 6. The distribution and severity of crop damage caused by wheat stem sawfly in 2021.**

***(vi) Bertha armyworm (BAW)***. Collaborators monitored 736 canola fields in Alberta, Saskatchewan, and Manitoba in 2020 (up approximately 16 fields from 2020). The phenology model for BAW development was used to predict the timing of larval pupation and adult emergence, and thus guide when pheromone traps were deployed. Generally, trap catches were low across the prairies in 2021, as in the past few years (Figure 7). There were very few traps that caught more than 300 adult male moths during the trapping period.

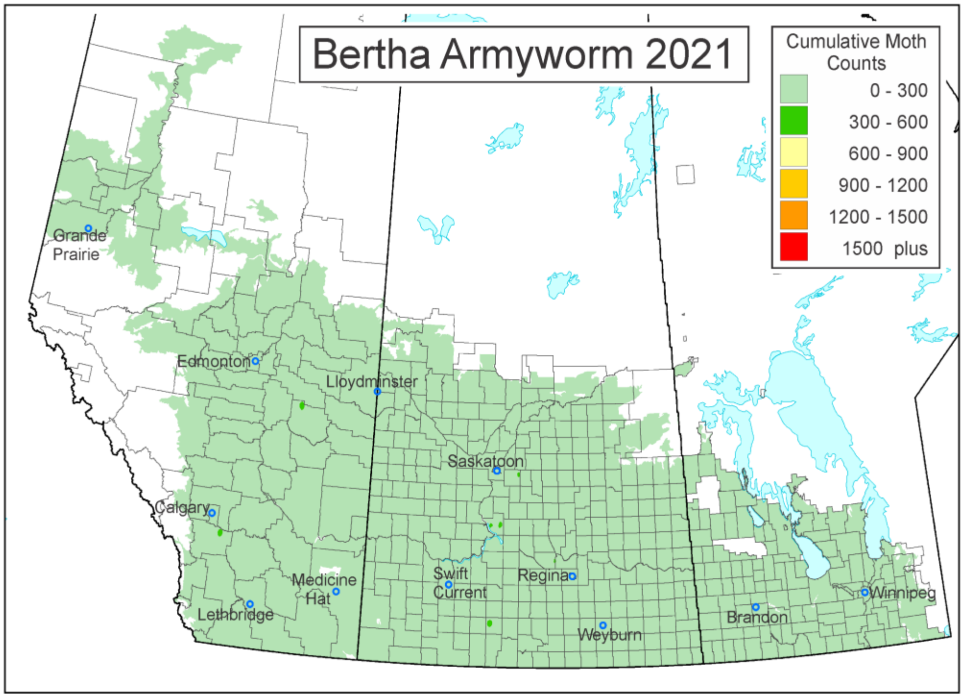


**Figure 7. The distribution and relative abundance of bertha armyworm moths in 2021.**

***(vii) Diamondback moth (DBM)***. Pheromone traps were installed at 187 field sites in 2021 to determine the time, distribution, and density of adult migrations from the USA & Mexico. Wind trajectory model output was analyzed on a daily basis beginning in April to assist in predicting moth migrations. The number of adult moths captured in 2021 varied widely, as in past years. Some fields with high densities of diamondback moth were reported in 2021; these may have resulted from late arrival of moths (because pheromone trap captures were low in the region around these fields), or may have resulted from rapid population growth of small populations of early arrivals that were not detected by the pheromone traps. The complete life cycle of diamondback moth varies in length and can be quite short in hot weather, as experienced in 2021.

***(iv) Lygus spp***. An annual survey in canola has been conducted in the Peace River region since 2003. In 2021, we surveyed 121 *B. napus* fields during the Annual Canola Survey of the Peace River region. Canola growth stages at the time of the survey ranged from bolting to early pod stages owing to the extremely dry spring growing conditions and heat dome that brought extreme temperatures over a nearly 20-day period commencing approximately June 24, 2021. The dominant underlying stubble type below the surveyed canola fields was wheat (48.8 %; n = 121 fields) followed by barley (19.8 %), pea (9.9 %), canola (6.6 %), oats (5.0 %), then creeping red fescue (2.5 %).

In 2021, a total of 28,111 arthropods were identified and assigned to 122 taxon units following the survey (comprised entirely of sweep-net sampling). Lygus densities increased over those observed in 2020 which was not surprising given the drier and warmer growing conditions in 2021. Densities of Lygus adults plus nymphs in commercial fields ranged widely over the region (mean = 7.4 per 10 sweeps; SEM = 0.68; range 0.2-34.6; n = 121 fields; Figure 9). Other notable insect pest densities were also recorded. No cabbage seedpod weevil were observed. Diamondback moth adults and larvae in sweeps were low (mean = 0.4 per 10 sweeps; SEM = 0.11; range 0-12.0). Bertha armyworm (larval instars 1-3) were evident (mean = 0.01 per 10 sweeps; SEM = 0.005; range 0-0.6). The prevalence of underlying wheat stubble contributed to the number of parasitoids of wheat midge found in sweep samples. *Macroglenes penetrans* was relatively common in canola fields surveyed (mean = 4.3 per 10 sweeps; SEM = 1.17; range 0-97.2), again demonstrating the value and importance of managing individual fields to augment natural enemies and support wider ecosystem services.

***(x) Beneficial Insects.*** Sweep net sampling during the cabbage seedpod weevil survey in Saskatchewan and Lygus spp. survey in the Peace River Region (AB and BC) were leveraged to collect data regarding populations of beneficial species in flowering canola fields. Beneficial insects identified in these samples included pollinators, predators, and parasitoids. Analysis of the 2021 samples from Saskatchewan is ongoing. All parasitoids and Hymenopteran pollinators were preserved and will be identified at a later date.

The 2021 Annual Canola Survey of the Peace River region generated sweep-net samples from 121 commercial fields of canola. In addition to identifying economic pest species, other insects are processed to species, genus or family-levels. Parasitoids included members of Chalcidoidea, Ichneumonidae, and Braconidae and were present in 87.6 % of fields sampled and occurred in higher densities (mean = 4.84 per 10 sweeps; SEM = 1.18; range 0-99.4; Figure 10) compared to 2020. The overall presence and densities of these parasitoid wasps was related to *Macroglenes penetrans*, the parasitoid attacking wheat midge, which was relatively common in canola fields surveyed (mean = 4.3 per 10 sweeps; SEM = 1.17; range 0-97.2). Predators included spiders (not harvestmen), lacewings, minute pirate bugs, ants, damsel bugs, plus ground beetles, ladybird beetles, and rove beetles. These groups were present in 82.6 % of fields, but at lower densities than the parasitoids (mean = 0.6 per 10 sweeps; SEM = 0.05; range 0-3.8; Figure 11). Note that sweep-net sampling is not an "ideal" method to assess the densities of generalist predators and likely underestimate their densities. Pollinators were separated into bee or fly species. Bee pollinators included honey, bumble, leafcutter and other native bees collected in sweep-net samples in only 13.2 % of fields sampled and occurred in anticipated low densities (mean = 0.03 per 10 sweeps; SEM = 0.01; range 0-0.4). Hymenopteran pollinators were low so populations were mapped using presence/absence points (Figure 12). Fly pollinators included adults of many species, some of which only live for 4-7 days. Fly pollinators were present in sweep-net samples collected in 38.0 % of fields sampled and occurred in low densities (mean = 0.1 per 10 sweeps; SEM = 0.02; range 0-1.4). Pest and beneficial arthropod distribution and density data continues to be shared in tandem to reinforce how arthropod species share the canola canopy and the impact of pest management decisions on all naturally occurring insect populations.

No emerging pests of concern were detected during survey activities conducted in 2021. Thus, no interaction with the CFIA was required.

The third objective of the PPMN is to develop and/or refine tools and technologies for identification, monitoring, and forecasting insect pest populations. In 2021, Mr. Dylan Sjolie completed the field and laboratory research for his MSc project studying the population dynamics of wheat stem sawfly. The results of his field research indicated that wheat stem sawfly larval mortality over the winter is negligible. Thus, by sampling fields in the fall and accounting for parasitism, we can make accurate estimates of wheat stem sawfly risk to wheat crops in the next growing season. This information can be incorporated into future forecasting models. In addition to Mr. Sjolie's research, grasshopper sentinel sites were sampled weekly for 16 years in Saskatchewan, ending in 2019 (due to the COVID-19 pandemic). These data were used to refine a DYMEX phenology model for migratory grasshopper (*Melanoplus sanguinipes*) that was published in last fiscal year (previously reported); we will resume sampling at sentinel sites in 2022. A grasshopper species composition survey was conducted in Saskatchewan in 2021 as part of an ongoing effort to account for differences in lifecycles between grasshopper species that affect the accuracy of grasshopper population forecasting.

Project collaborators supported the Field Heroes campaign on Twitter. We also recorded episodes of the *Pests and Predators* podcast series that aired in 2021. We are in the process of recording a new series of podcasts for spring 2022. Very limited in-person outreach was possible in 2021, however, PPMN members spoke at various virtual events where they promoted the important role of beneficial insects in pest management and crop production.

In 2021, Weekly Updates were published on the PPMN website, starting in early May and ending in late August. As in the past, some Weekly Updates featured work related to pest monitoring that is not currently included in the PPMN mandate, including a new harmonized protocol for monitoring European corn borer in a variety of crop plants (developed by the Canadian Plant Health Council Insect Community of Practice). In addition to Weekly Updates, the *Insect of the Week* feature was continued in 2021. We took advantage of time spent working from home to work on new materials for the website and to expanding insect photo libraries.

## 5. Discussion

In 2021, work to address all of the project objectives was completed with considerations taken to protect the health and safety of the PPMN members and the general public due to the ongoing global COVID-19 pandemic. The number of field sites monitored for insect pests increased in 2021 for most insect pests. The success of the PPMN during the global COVID-19 pandemic is a testament to the collaborative nature of the Network and the importance of pest monitoring for the benefit of the agricultural industry in western Canada.

**Report compiled by Dr. Meghan Vankosky. This report is a summary of the annual activity report submitted to the Integrated Crop Agronomy Cluster in spring 2022.**