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A Canadian Approach to Sustainable Pollination

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The authors are part of NSERC-CANPOLIN, School of Environmental Sciences, Edmund C. Bovey Building, University of Guelph, Ontario, Canada. *The Canadian Pollination Initiative (NSERC-CANPOLIN) is a five-year, $5 million research network that has been investigating the complex issues of pollinator declines and sustainable pollination since it was launched in 2009.*

Research on pollination and pollinators in Canada is getting a major boost in support thanks to a recently created NSERC Strategic Network. The unique hallmark of NSERC-CANPOLIN is that it transcends many of the cross-disciplinary barriers that have traditionally hampered pollination research. Over 45 university and government researchers across the country are engaged in the Network; entomologists, apiculturists, crop producers, plant biologists, ecologists, genomicists, modellers and economists are working together to study all aspects of the critical ecosystem service of pollination, including all major groups of pollinators, the pollination of all groups of plants, all types of pollinator habitat, and the economic and environmental aspects of pollination. This integrated, broad-spectrum approach is key to addressing the full scope of the pollination problem, whether it be in Canada or elsewhere.

Improving the health and disease resistance of *Apis mellifera* is a major focus of NSERC-CANPOLIN's research activities.

Photo: M. Horn

Research activities fall under four broad interdisciplinary themes: *Pollinators*, *Plants*, *Ecosystems*, and *Prediction and Economics*.

Pollinators: This theme includes both managed and wild pollinators. The health and efficiency of managed bees (especially honey, bumble, and alfalfa leaf cutting bees) is being investigated, with the goal of developing new technologies and strategies for disease management. Wild pollinator research is focused on the diversity, taxonomy, conservation, and bionomics of native species. Taxonomic treatises and practical guides are already in preparation for certain families of bees, flies, butterflies and moths. Many keys will be made available online via the *Canadian Journal of Arthropod Identification* (www.biology.ualberta.ca/bsc/ejournal/ejournal.html) (i.e. Packer *et al.* 2007; Kits *et al.* 2008), and are lavishly illustrated for use by researchers and amateurs alike. Wild pollinators are being assessed in natural, agricultural, and urban systems for diversity, abundance, and activity, partly in cooperation with the Barcode of Life Initiative (Packer *et al.* 2008; Sheffield *et al.* 2009). Conservation research will focus on availability and sustainability of pollination services in different ecosystems, in addition to the economics of wild pollinator conservation to provide pollination services in crops.

NSERC-CANPOLIN will also explore how to maximise the effectiveness of crop pollinators for high quality produce.

Photo: S. Bates

Over the life of the Network, NSERC-CANPOLIN will invest approximately $400,000 in honey bee apiculture research; this amount is expected to double through collaborations and contributions from organizations across the country. This represents a huge boost for apicultural research at a critically important time (Kevan *et al.* 2007). As NSERC-CANPOLIN evolves, benefits are expect to flow to the technology and husbandry of leafcutting bees, bumble bees, orchard bees, and wild pollinators. Current projects for managed pollinators include:

1) A national survey of honey bee pathogens and parasites (Currie *et al.* 2010; Eberl *et al. in press*)
2) The establishment of a national bee pathogen diagnostics laboratory.
3) A breeding program for honey bee resistance to American Foulbrood Disease.
4) Increasing honey bee immunity to *Nosema apis* and *N. ceranae*.
5) Testing microencapsulated medicaments in pollen substitutes for disease control.

6) Developing and testing material dispensers and hive components to deploy biocontrol agents and dusts against honey bee pests while improving efficiency in hive air flow (Sudarsan *et al.* 2009).
7) Impacts of pesticides on honey bees and other pollinators.

University of Manitoba researcher measures formic acid concentrations in colonies treated for *Varroa* mites.

Photo: R. Currie

Lethal and sublethal pesticide toxicity to honey bees, alternative managed pollinators, and wild pollinator species has emerged as an issue of critical importance (Scott-Dupree *et al.* 2009). Although some studies demonstrate minimal or no effects of certain insecticides on pollinators (i.e. Franklin *et al.* 2004; Cutler and Scott-Dupree 2007), others have demonstrated that toxic effects exist (i.e. Yang *et al.* 2008; Scott-Dupree *et al.* 2009). It is important to ensure that products or application methods harmful to pollinators, whether they have lethal or sublethal effects that may impair pollination capability, are identified and avoided. Additional projects are being initiated to address issues confronting alfalfa leafcutting bees as pollinators for alfalfa seed production, and to evaluate alternative pollinators in many other crops (including tree fruits, vine crops, canola, blueberry). The Network will also examine the simultaneous use of managed bumble bees as pollinators and as vectors of biological control agents in greenhouse crop production (Kevan *et al.* 2003; Al-Mazra'awi *et al.* 2006a; Kapongo *et al.* 2008) and canola (Al-Mazra'awi *et al.* 2006b). Investigations

An important pollinator in greenhouses, a bumble bee visits a tomato plant..

Photo: A. Morse

adapting the technology to some berry crops (blueberries, strawberries, raspberries) are also underway.

Plants: This theme will address the lack of data on the reproductive systems of wild Canadian flora and their pollination needs, in addition to those of established and potential crops. Such data are needed to determine the role of pollinators in ecosystem functioning and sustainability, and to identify which plants are most at risk from declining pollinators. The importance of pollination and plant reproductive systems in crops of interest (e.g. lowbush blueberry, canola, cherries) will be tackled by special interdisciplinary focus groups ("hit teams") to address pollination and production issues. One important concern in this area is the potential shortage of pollinators for hybrid canola seed production as acreage increases: how can beekeepers sustain their apiary operation after the brief period of canola bloom? Building on past research, new studies on gene flow are shedding light on pollen movement in target plants such as blueberries (Usui *et al.* 2005), while other work is exploring the role of pollination in hybridization and the spread of invasive plants. Additional work in pollination of economically important greenhouse crops such as tomato and sweet pepper is also planned (Kevan *et al.* 1991, Morandin *et al.* 2001a,b, Morse 2009).

The Plant theme also encompasses pollen production and dispersal in wind pollinated plants, a major component of most Canadian ecosystems. The importance of mixed wind/insect pollination systems is probably much greater than generally realized (DiGiovanni and Kevan 1991), and will be subject to interdisciplinary investigations following the example of studies such as Kevan (1994) and Melendez *et al.* (2000).

A Malaise trap collecting insects near Churchil, Manitoba.

Photo: T.Woodcock

Ecosystems: Pollination is a critical process that is central to the sustainable functioning of all ecosystems. The Ecosystems theme combines the floral and faunistic studies in an ecological context for urban, agricultural, and natural ecosystems and landscapes. Researchers are examining a range of factors affecting plant and pollinator diversity and functioning across Canada, including habitat loss, fragmentation, competition for pollinators with non-native plants, agricultural and forestry practices, climate

Wild pollinators such as this syrphid fly are important in both agricultural and natural ecosystems.

Photo: T. Woodcock

change, and interactions between these factors. Sampling activities have been initiated in all major ecozones across the country, including the Arctic.

Ecosystems with a strong human influence, such as urban and agricultural areas, can have reduced pollinator food and habitat resources due to a reduction in plant species richness and major disruption to soils and other habitat types. Conservation of pollination services is of paramount importance in these systems, particularly those supporting food production (Ricketts *et al.* 2008). Managed honey bees are often the pollinator of choice in agricultural ecosystems; however, the role of other managed pollinators and native bees needs to be investigated, particularly in the face of potential honey bee declines (Kevan *et al.* 2007; Currie *et al.* 2010). A better understanding of pollination services in our crops can improve yields, increase profitability for growers, and help conserve wild pollinators in rural landscapes (i.e. Morandin *et al.* 2007). At the local level, NSERC-CANPOLIN is also involved in assessing urban pollinator populations, and using pollination services as a focus for the restoration of disturbed ecosystems such as decommissioned landfills (Kevan and Savage 2008) and gravel pits (Woodcock *et al.* 2009).

Natural ecosystems are inherently more complex than agricultural or urban systems and the effects of stresses are thus more difficult to quantify. Although there is evidence that many ecosystem functions are resilient to loss of biodiversity (Schwartz *et al.* 2000), pollination efficiency appears to be an exception because of its central role in maintaining healthy plant communities (Fontaine *et al.* 2006; Vamosi *et al.* 2006) and the extensive plant-pollinator mutualisms required to do so (Parachnowitsch and Elle 2005; Robson 2008). NSERC-CANPOLIN is devoting considerable effort to fundamental ecological research. This effort includes sampling pollinator communities in 25 national parks and other areas, creating a database of native plant mating systems, and constructing pollination connectance webs at a variety of scales.

Prediction & Economics: A major goal of NSERC-CANPOLIN is to predict future pollination management needs in both agricultural and natural systems, particularly as they relate to climate and land use changes. The Prediction group is using modelling and geomatics techniques to investigate how ranges and abundance of pollinator species are expected to change over the coming decades (White and Kerr 2006; Kharouba *et al.* 2009). An extensive databasing effort for several groups of pollinators (bees, flower flies, Lepidoptera) is underway, including specimens in collections across North America. Information on species' historical ranges will allow comparison with ongoing sampling efforts, and relation to climate data. This approach has already implicated climate-change related drying to the precipitous decline of *Bombus affinis*, which has virtually disappeared from most of its historical range (J.T. Kerr, *personal communication*).

The Economics group is providing analyses that will highlight the potential economic impacts and provide critical linkages to policy making. Pollinator shortages can impact both the ecology of crop production and commodity pricing and availability (Kevan and Philips 2001). A modern economic analysis of the third player in the economics of pollination, the honey bee industry, has not previously been undertaken in Canada and is currently underway. The next report will focus on the value of apiculture to pollination, food production, and food security in Canada. Both reports will be invaluable in developing solutions and targeting research efforts for an industry that has had more than its share of problems in recent years.

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