Bees and pollination in British Columbia

PAUL VAN WESTENDORP

BC MINISTRY OF AGRICULTURE, FOOD & FISHERIES,
1767 ANGUS CAMPBELL ROAD, ABBOTSFORD, BC, CANADA V3G 2M3

DOUG M. McCUTCHEON

BEE BOOKS & THINGS,
2525 PHILLIPS STREET, ARMSTRONG, BC, CANADA V0E 1B1

Bees co-evolved with flowering plants. Their wasp-like ancestors modified their diet and behavior in order to utilize the floral food resources that became available some 90 million years ago. In turn, plants were able to accelerate species diversification. The interdependency between flowering plants, especially fruit-bearing plants and insect pollinators became obligatory and in some cases developed into extreme specialization. In general, the abundance and species diversity of insect pollinators play a critical role in the ecology of many habitats in the world. Economic interests and demand for optimized yields in modern crop production systems have intensified the interdependency between crops and insect pollinators.

British Columbia's temperate environment and habitat diversity has facilitated the evolution of a rich pollinator fauna. The majority of its indigenous pollinators are solitary bees, characterized by the female establishing a nest on her own, and provisioning each cell with pollen, nectar and an egg. Many solitary bee species are gregarious and nest in the soil.

In comparison, only a small number of social bee species are indigenous to BC. These include bumblebees (*Bombus* spp.) characterized by one female (queen) having assumed sole responsibility of egg laying while all other individuals are sterile workers and males (drones). The vast majority of the offspring are workers responsible for food gathering, nest building, brood rearing and protection.

Winston and Graf (1982) identified six families of solitary bees in BC. These included *Halictus, Andrena, Auqochlora, Chelastoma, Melissodes* and *Xylocopa*. In 1987, Scott-Dupree and Winston (1987) examined the diversity of bees in Okanagan Valley orchards and found *Halictus spp.* most abundant, followed by *Andrena, Megachilidae* and *Anthophoridae*. Among bumblebees, *Bombus terricola* was most often recorded followed by *B. bifarius*, while at least ten additional species were noted. Mackenzie and Winston (1984) found *B. mixtus* the most abundant species in Fraser Valley berry crops followed by *B. occidentalis*, *B. terricola* and *B. flavifrons*.

Management of Bee Species for Crop Pollination

Although all bees play an important role in the ecology of most habitats, the development of agriculture in the province magnified the significance of their role (Matheson *et al.* 1996). John Corner, BC Provincial Apiarist from 1950 to 1983, assessed the suitability of using wild bees to improve pollination of various crops (Corner 1963). Corner selected the alkali bee *Nomia melanderi* for further trials. These bees were gregarious ground nesters from Oregon and were used in alfalfa pollination on a limited scale. Soil beds were established adjacent to alfalfa fields near Ashcroft and Kamloops and soil cores containing larvae were imported and successfully introduced. The bees became well established but the project was abandoned, as alfalfa seed production remained limited in the southern interior. Management suitability of *Bombus* spp. was also assessed in the Peace region for the pollination of red clover *Trifolium pratense*. The long-tongued species of *B. californicus* and *B. auricomis* were identified as most effective pollinators while *B.bifarius nearcticus* was deemed unsuitable.

Other trials involved the alfalfa leafcutter bee *Megachile rotundata* at sites in Creston, Vernon, Kamloops, Williams Lake and Peace River. Although leafcutter bee management proved successful under BC conditions, the alfalfa growers' unfamiliarity with seed production caused the abandonment of the projects in southern and central BC. Leaf cutter management proved a successful enterprise for some Peace operations specialized in alfalfa seed production.

Scott-Dupree and Winston (1987) noted a low count of the indigenous Blue Orchard Mason Bee *Osmia lignaria* in Okanagan orchards. This solitary and gregarious species had been previously identified for its manageability and excellent pollination characteristics under poor weather conditions. Scott-Dupree recommended this species be considered for management in BC's tree fruit and berry crops. In the same study, *B. occidentalis* and *B. nearcticus* were also suggested as candidates for commercial use. Since then, *O. lignaria* was never adopted as a significant pollinator in commercial crops, but it has gained considerable popularity among gardeners in urban settings in recent years.

Researchers have assessed the management and rearing suitability of a wide range of insect pollinators over many years. Pollinators with unique characteristics may still be selected for special crop pollination requirements in the future. Yet, of more than 4,000 insect pollinators identified in North America, only a few species have ever been managed in significant numbers for crop pollination purposes. These include the non-indigenous honeybee *Apis mellifera* L., two species of bumblebees (*B. occidentalis* and *B. impatiens*), the alfalfa leafcutter bee *M. rotundata*, and the Orchard Mason Bee *O. lignaria*.

Orchard Mason Bees

The Orchard Mason Bee (also called the Blue Orchard bee, Mason Bee or Osmia Bee) is the ideal 'urban bee'. During the 1990s, *O. lignaria propingua* became popular in urban garden settings because of its non-defensive behavior, low maintenance, and high pollinating efficiency in early blooming fruit bearing plants. Its popularization was further enhanced with the introduction of 'condominiums' or nest boxes that are now commercially available at garden centers and selected nurseries. Many initial enthusiasts were former beekeepers who no longer kept honeybee colonies following the introduction of the obligate parasitic mite *Varroa destructor* (formerly *V. jacobsoni* Oudemans).

The Osmia Bee has nesting behavior similar to *M. rotundata* where the gregarious female selects a tubular cavity where she lays up to 10 eggs in succession, each provisioned with nectar and pollen, and closed off with a plug. Since reproduction rates remain limited, this pollinator is not considered suitable as a primary crop pollinator in large-scale settings.

Bumblebees

Over 30 indigenous species of bumblebees (affectionately called 'Bumbles') have been identified in BC. The bumblebee tolerance to poor weather conditions has made this insect an ideal pollinator of early blooming plants. The characteristic 'buzzing' causes sticky, moist pollen grains to be dislodged, further enhancing the bumblebee's pollinating versatility. While honeybees have a complex communication system enabling them to utilize pollen and nectar sources over great distances, the bumblebee's solitary, non-directional food gathering limits its foraging range and makes it an ideal pollinator in the confined space of the greenhouse. Their smaller nests and comparatively low defensive behavior also reduces conflict with greenhouse workers. Bumblebees have become the principal pollinators in greenhouse tomato production providing higher crop yields, improved quality and earlier maturation at substantially lower costs than manual pollination. In BC, growers purchase nest boxes from eastern Canadian suppliers that include the indigenous *Bombus occidentalis* and the non-indigenous *Bombus impatiens*.

Honeybees

Honeybees are not indigenous to the Americas. They were first brought to North America from Europe in the 1600s. The first introduction of honeybees in BC was in the 1850s. Initially, these colonies were not prolific as most of the natural vegetation of the province did not offer sufficient nectar and pollen sources. As agricultural activities expanded in southwestern BC and the Okanagan, honeybees became well established.

The introduction of intensive agricultural practices in modern times has made the honeybee indispensable. Monocultural practices, pesticides, and the alteration of the soil and natural vegetation have contributed to the decline in the abundance and species diversity of wild insect pollinators (Matheson *et al.* 1996). Even with a natural abundance of pollinators, the pollination requirements of monocultural crop management systems can not be met. It has been estimated that an hectare of mature highbush blueberries produce 9 – 10 million flowers in spring when weather conditions are often not conducive to insect foraging activity. Only honeybee colonies with their large populations can meet crop pollination requirements at the time of bloom. The value of annual crop production in BC attributable to honeybee pollination has been estimated at over $161 million (Anon. 1999). For Canada, this value is estimated at approximately $700 million (Scott-Dupree 1995). In the USA with its milder climates, honeybee pollination has been valued at over $14 billion worth of agricultural production per year (Morse and Calderone 2000).

The first reference to using honeybees in pollinating crops for a fee was in the 1953 Annual Report of the BC Department of Agriculture. A total of 155 colonies were rented for tree fruit pollination at $2.50 - $6 per colony. By 1975, 5000 hive sets were recorded at an average pollination fee of $15 per colony. During the 1990s, 29,000 hive sets were rented each year with fees ranging from $50 in tree fruit orchards to $90 in cranberry *Vaccinium macrocarpon*. With the ongoing expansion of berry crops in the Fraser Valley and high-density plantings of tree fruits in the Okanagan, the demand for honeybee pollinating units has increased to 47,000 in 2001.

Honeybee Diseases and Pests

The perennial colony nest of honeybees offers ideal conditions to a range of pathogenic and non-pathogenic organisms. In 1586, Jacob of Germany first described American Foulbrood disease (AFB) caused by the spore-forming bacterium *Paenibacillus larvae* (formerly *Bacillus larvae* L.) (Otten 1999). The highly resistant spores remain viable for decades and pose a source of infection to bee brood in any infected hive equipment. Many countries in the world have enacted legislation to control the disease, which has traditionally involved the depopulation of colonies followed by burning of all the equipment. In the 1950s, antibiotics were introduced enabling beekeepers to control AFB effectively. However, the bacterial spores would not be killed but merely prevented of germination. The incessant use of antibiotics in beekeeping management has led to the development of antibiotic-resistant strains of *P. larvae* (r-AFB) in recent years.

Other bee brood diseases include European Foulbrood (*Bacillus alvei*), Chalkbrood (*Ascosphaera apis*) and viral diseases such as Sacbrood. Most of these ailments are stress related and can be managed relatively easily by the beekeeper. Nosema disease caused by the protozoan *Nosema apis* affects the midgut and ventriculus of adult bees, causing impairment in nutrient absorption. Effective control is obtained with the application of the antibiotic fumagillin.

With the arrival of parasitic mites, beekeeping changed radically. In 1986, the first infestation of the microscopic mite *Acarapis woodi* was confirmed in BC. Initially, the impact of this mite, affecting the tracheal tubes of adult bees, was much feared because of the widespread destruction of colonies that had been reported on the Isle of Wight in 1919. Since then, the tracheal mite has proven manageable for most beekeepers. Comparative studies on tracheal mite resistance in honeybees during the 1990s showed that resistant strains occurred in BC. Through selection, many beekeepers developed beestock with some level of tracheal mite resistance.

The first infestation of the highly destructive mite *Varroa destructor* was confirmed in 1990. Despite efforts to isolate the pest through colony movement restrictions, the mite eventually spread to most beekeeping areas in BC. *V. destructor* originated in Southeast Asia where it was a common pest of the eastern honeybee, *Apis cerana*. With the introduction of the western or European honeybee, the mite found a perfect host without defenses parasitizing brood and adult bees.

The high pathogenicity of *V. destructor* invariably leads to the demise of the colony if no controls are applied. In Canada, formic acid and the synthetic pyrethroid *fluvalinate* marketed under the trade name Apistan, have been registered to control this pest. The development of Apistan-resistant mites signals the end of the usefulness of this product. There are currently efforts to obtain an emergency registration of Coumaphos of Bayer, while other control methodologies are being sought at various research facilities in North America.

Use of Hive Products

Honey is the end product bees produce from the collection of floral nectar sources. While nectar is a sugary solution containing approximately 80% water, honey is a solution of enzymatically converted monosaccharides containing between 14 and 20% water. Its low water content prevents microbial growth and when kept airtight and in cool conditions, honey can be stored for many years. Virtually all stored honeys will undergo the physical process of crystallization over time. The rate or crystallization is determined by the relative abundance of the different sugars. Reversal to liquid honey can be accomplished through warming and stirring. In North America, honey is viewed as a fancy alternative sweetener to table sugar. In most other countries of the world honey is regarded as a scarce and valuable product to which many medicinal qualities are ascribed. While per capita consumption of honey in Canada is only 0.86 kg per annum, consumption in the Middle East exceeds 10 kg per capita per annum (Anon. 2001).

Pollen constitutes the primary protein source needed for brood rearing. Through special management, some beekeepers collect pollen for feeding to bees at a future date, for sale to other beekeepers, or for human consumption. Some of the pollen is also collected as a nutrient supplement for racehorses. The total amount of pollen sold for commercial purposes is limited.

Propolis (Pro – *for*; polis – *the community)* is a resinous material collected from floral and foliar buds. The material is used for plugging holes in the nest cavity, or encasing and mummifying foreign materials inside the nest that bees can't remove. Its strong anti-microbial and hydrophobic properties have long been recognized, from the ancient Egyptians to today's pharmaceutical industry.

Bee venom has long been used for controlling rheumatoid arthritis and various other ailments. A collection device has been developed where bees release their venom when exposed to a small electric charge. The pharmaceutical industry is the primary market although in recent years, the alternative medicinal practice of apitherapy has gained popularity.

Royal jelly is a protein-rich excretion of the hypo-pharyngeal glands in young worker bees. The material is the principal food source of the queen throughout her life. Worker brood is only fed small quantities of royal jelly mixed with honey and pollen during early larval development. High labor costs in colony management and harvesting have prevented commercial production of royal jelly in North America and Europe. The world's largest producers include China and Korea.

Queen and Honeybee Stock Production

Prolonged winter conditions have always been among the most important stress factors to honeybee colonies. Average winter mortality has been about 16% for the province but in some northern regions average losses have often been much higher. To replace winter losses and improve the quality of stock, beekeepers purchase queens or package bees (a cage containing approximately 8,000 bees and a queen) from breeders. In former times, large-scale commercial operators in the Peace region purchased thousands of packages from California each spring to stock their hives. These "package operators" killed off all their colonies after the honey harvest, as wintering was considered too costly and expensive. When parasitic mites were first discovered in the US, Canada closed its borders to the import of bees from the US, forcing Canadian beekeepers to winter their bees and rely on domestically produced beestock or bees imported from Australia and New Zealand. Most of the domestic bee breeders became established in coastal BC. Due to high production costs and late availability in spring, the growth potential of this sector remains limited.

REFERENCES

Anon. 1999. Factsheet #504. Apiculture Program, BC Ministry of Agriculture and Food.

Anon. 2001. World honey market. American Bee Journal 141(12): 859.

Corner, J. 1963. Annual Report, Apiculture Program, BC Department of Agriculture, Internal Document, Unpublished.

Matheson, A., S.L. Buchmann, C. O'Toole, P. Westrich and I.H. Williams. 1996. The Conservation of Bees. Linnean Society of London and the International Bee Research Association. Academic Press, London.

McKenzie, K.E. and M.L. Winston. 1984. Diversity and abundance of native bee pollinators in berry crops and natural vegetation in the lower Fraser Valley, British Columbia. The Canadian Entomologist 116: 965-974.

Morse, R.A. and N.W. Calderone. 2000. The value of honey bees as pollinators of US crops in 2000. Bee Culture, http://bee.airoot.com/beeculture/pollination2000/pg1.html

Otten, C. 1999. Epidemiology of the American Foulbrood in Germany. Proceedings Apimondia '99 Congress, Vancouver, BC. Pp. 52-53.

Scott-Dupree, C. (Ed.). 1995. A Guide to Managing Bees for Crop Pollination. Canadian Association of Professional Apiculturists.

Scott-Dupree, C.D. and M.L. Winston. 1987. Wild bee pollinator diversity and abundance in orchard and uncultured habitats in the Okanagan Valley, British Columbia. The Canadian Entomologist 119: 735-745.

Winston, M.L. and L.H. Graf. 1982. Native pollinators of berry crops in the Fraser Valley of British Columbia. Journal of the Entomological Society of British Columbia 79: 14-20.