Flower sharing and pollinator health: a behavioural perspective

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Supplementary Materials

Table S1. List of some key papers that investigated indirect transmission of pathogens in bees through shared use of flowers. Main reported results related to route of transmission are indicated. F.S., suggested fecal-oral transmission; O.A., transmission through oral contact with artificially contaminated flowers; O.S.S., suggested oral transmission through contamination of flowers with bee oral secretions; Flw.S., suggested indirect transmission through shared use of flowers, specific route unknown; DWV, deformed wing virus; SBV, sacbrood bee virus; BQCV, black queen cell virus; ABPV, acute bee paralysis virus; IAPV, Israeli acute paralysis virus; KBV, kashmir bee virus; CBPV, chronic bee paralysis virus.

Route	Pathogens	Bee species	Experiment	Results	Ref.
O.A.	*Crithidia bombi*	*Bombus impatiens*	Role of floral traits, bee size and foraging behavior on transmission of *C. bombi* in bumblebees by adding controlled amounts of inoculum to flowers and assessing susceptibility of bees foraging in the inoculated flowers	Smaller bumblebees and those that forage for longer are more susceptible to *C. bombi* infection. Bee susceptibility and intensity of infection rise with the number of reproductive structures per flower in the different plant species.	[1]
F.S. O.S.S.	DWV, BQCV	*Apis mellifera,* *Bombus vagans,* *B. bimaculatus*	Analysis of RNA viruses in bumblebees and flowers collected near and far from apiaries containing honeybees infected by these viruses	Prevalence and active infections of DWV were higher in bumblebees collected near apiaries with high infection levels.	[2]

F.S. O.S.S.	DWV, BQCV	*Apis mellifera,* *Bombus sp.*	Likelihood of honeybees depositing viruses on flowers and of bumblebees becoming infected after visiting them; influence of flower architecture and bee visitation rates on the likelihood of virus deposition on flowers	Honeybees deposit viruses on flowers. Flowering plant species and/or bee behavior influence the likelihood of virus deposition.	[3]
F.S. O.S.S. O.A.	DWV	*Apis mellifera,* *Bombus impatiens*	Inter-specific viral transmission through use of flowers previously visited by infected bees or artificially inoculated with DWV; influence of foraging time and dosage acquired in the susceptibility to infection	DWV can be transmitted from infected honeybees to bumblebees, and *vice versa*, through the use of shared flowers.	[4]
F.S. O.A.	*Crithidia bombi*	*Bombus lucorum,* *B. terrestris*	Inter-specific transmission of parasites through use of flowers previously visited by infected bees, or artificially inoculated; influence of flower architecture on transmissibility	*C. bombi* can be horizontally transmitted through the shared use of flowers. Nectar availability or inflorescence architecture may also affect transmission rate.	[5]
F.S.	DWV, SBV, BQCV, ABPV, IAPV, KBV, CBPV	29 bee species	Prevalence of 7 viruses in bee communities that share the same small surface of floral resource, in order to assess the risk of virus spillover	Evidence of DWV spillover from honeybees to bumblebees. High prevalence of the honeybee viruses in wild bee species	[6]

F.S.	*Crithidia bombi*	*Bombus impatiens*	Influence of host infection and plant species on pathogen deposition on flowers. Influence of plant species and flower parts on pathogen survival and acquisition at flowers	Efficiency of pathogen transmission depends on where deposition occurs and the timing and place of acquisition, which varies among plant species and environmental conditions.	[7]
F.S.	*Nosema ceranae, N. apis, N. bombi, Trypanoso-matida, Neogrega-rina*	46 bee species	Combination of mathematical modelling and data from 11 bipartite plant-pollinator networks observed along a landscape simplification gradient to elucidate how changes in network structure shape disease dynamics	Landscape simplification reduces pathogen prevalence in bee communities via increased diet breadth of the dominant species. Increased connectance reduces the likelihood of a disease outbreak and decreases variance in prevalence among bee species in the community.	[8]
F.S.	*Nosema ceranae, N. apis, N. bombi, Crithidia. bombi, Apicystis bombi*	*Apis mellifera,* *Bombus terrestris*	Potential for flowers to act as dispersal platforms for pollinator parasites, and for non-host species to vector them, using bumblebees and honeybees as both hosts and vectors	Three bumblebee parasites and two honeybee parasites were dispersed effectively onto flowers by their hosts, and then vectored readily between flowers by non-host pollinator species.	[9]
F.S.	*Nosema ceranae, N. bombi, Crithidia bombi, C.expoeki,* Neogrega-rina	110 bee species	Screening of 110 bee species and 89 flower species over an entire foraging season for five common bee microparasites, to elucidate if plant and bee abundance, diversity and/or composition is associated with changes in parasite prevalence	Bee communities had the highest prevalence late in the season, when social bees (*Bombus* spp. and *Apis mellifera*) were dominant and bee diversity was lowest. Conversely, prevalence on flowers was lowest late in the season when floral abundance was highest.	[10]

Flw.S	DWV, SBV, BQCV, ABPV, IAPV, KBV, CBPV	*Apis mellifera,* *Megachile rotundata*	*M. rotundata* adults placed alongside or far from honeybee hives were examined for the presence of seven viruses commonly found in honeybees.	SBV and DWV were detected in *M. rotundata* but their presence appeared independent of whether honey bees were present in the same field or not.	[11]
F.S.	*Nosema ceranae*	*Apis mellifera,* *Tetragonula hockingsi*	Transmission of *N. ceranae* in *T. hockingsi* through use of flowers previously visited by infected honeybees	Flowers are an effective means of transmission of *N. ceranae* between *A. mellifera* and *T. hockingsi*.	[12]
F.S.	*Crithidia bombi*	*Bombus impatiens*	Infected “donor” bumblebee microcolony of large or small workers were placed in field tents with uninfected average-sized “recipient” microcolony and allowing bees to forage for 9-16 days.	Larger bees foraged more and produced more faeces, being twice as likely to transmit *C. bombi* to recipient bees than smaller bees.	[13]
F.S.	IAPV	*Apis mellifera,* *Bombus impatiens*	IAPV-infected honeybees and IAPV-free bumblebees, and *vice versa*, were housed in greenhouses and allowed to forage by providing common food sources.	IAPV could be transmitted between honey bees and bumblebees with the only contact being common visits to flowers.	[14]

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