A Summary of the Varroa-Virus Disease Complex in Honey Bees

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Varroa destructor destroys colonies of European races of the Western honey bee (*Apis mellifera*) in two ways through ectoparasitic feeding on the mature and immature bees and by transmitting the viruses among bees. Researchers have shown that these mites transmit a number of viro-pathogens (Tables 1 and 2), but there has been no compendium of those pathogens to indicate to the beekeeping industry the breadth and extent of the problem. Anderson (1995) provides a useful review of the viruses associated with *A. mellifera* and the Asiatic Hive Bee, *A. cerana*. He also notes the relationship of the viruses with other pathogens and parasites. We have summarized that information in Table 1. In this short article, we review briefly the diversity of virus pathogens of honey bees that have been associated with *V. destructor*. Other virus transmitters, like *Nosema apis* and *Malpighamoeba mellificae* that cause dysentery in honey bees, are known but the viruses they can transmit seem to cause little harm to the honey bees.

So far, about 20 viruses infecting honey bees have been identified (Ostiguy 2004). Some of the more serious pathogens are sacbrood virus, deformed winged virus (DWV), and chronic and acute paralysis virus (CBPV and ABPV). Some of the other viruses are mild or negligible in their effects. Table 1 presents a list of virus diseases, and Table 2 notes the evidence of their association with *V. destructor* and modes of transmission. The mites transmit viruses to their hosts through their saliva when feeding. The feeding habits of the mites, apparently sharing and repeatedly using the same wounds (Kanbar and Engels 2005), would increase the levels and chances of infection. Moreover, it is also reported that the saliva of mites may contain substances that interfere with the bee's immune system (Table 2). Viruses also can be transmitted from bee to bee in several ways, e.g., through eggs, larvae, pupae, and adults; food, feeding, and feces (Table 2). It is also reported that viruses occurs in honey (Table 2).

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No, this is NOT a staged picture! Last October some colonies were dying and being robbed. On close inspection they were having very severe cases of PMS (parasitic mite syndrome). Very few brood cells were left and when I opened these cells, some had more than 20 mites per cell! This one had 12 mites just near the top. Most of the time the larvae were already dead inside cells (this one looks alive). (Photo by Dr. Zachary Huang, Michigan State University, www.beetography.com)

Conclusion

Colonies of honey bees are in increased demand for pollination services, as well as for honey and other bee products. In many countries apiculture is a profitable business with thousands of people involved. However, diseases of bees and hives have caused serious problems, even contributing to a decline in beekeeping. The spread of mite parasites throughout North America has created many difficulties for beekeepers. Moreover, the problems have become exacerbated by the evolution of pesticide resistance in the mites. Now, the added complexity of multiple infections, such as by *Varroa* and viruses, must be addressed as colonies affected must surely be weakened more than by either pathogen alone. This short summary, with its table of information, is intended to provide insights into the potential extent of the problem, and the amount of research that is being undertaken to address the situation.

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Table 1. Virus infections of honey bees (*Apis mellifera* unless otherwise noted). Those listed in Bold are recorded as having been transmitted by *Varroa destructor*.

VIRUS	SYMPTOMS	REFERENCE
ABPV = Acute Bee Paralysis Virus	Kills larvae, pupae, and adults only in association with Varroa, otherwise bees seem healthy.	Anderson 1995; Bailey et al. 1979
BQCV = Black Queen Cell Virus	Affects queen prepupae and pupae sealed in cells. They become pale, then darken, staining the cell. Mostly in association with *Nosema apis*.	Anderson 1995
BXV = Bee Virus X	Reduces life span of adult bees	Bailey 1981
BYV= Bee Virus Y	Associated with *Nosema apis*	Anderson 1995
CBPV = Chronic Bee Paralysis Virus	Infected bees become listless crawlers with trembling to dislocated wings, and are often hairless and greasy in appearance.	Anderson 1995
CWV = Cloudy Wing Virus	Wings sometimes somewhat opaque	Hornitzky 1987
DWV = Deformed Wing Virus	Deformed wings and short survival time (<48 hrs) when infection is high.	Yang & Cox-Foster 2005
KBV = Kashmir Bee Virus	Apparently more or less harmless unless associated with other pathogens such as *Nosema apis* and *Melissococcus pluton*. Infects both *A. cerana* and *A. mellifera*.	Anderson 1995
KV = Kakugo Virus	Aggression (virus is found in the brain).	Fujiyuki et al. 2004
SBV = Sac Brood Virus	Sac brood.	
SBPV = Slow Bee Paralysis Virus	Kills bees after about 12 days, Paralysis of fore legs.	Anderson 1995
TSBV = Thai Sac Brood Virus	Sac brood of *A. cerana*.	
Arkansas Bee Virus	Suggested to kill bees slowly. Often masked by infection by CBPV.	
S-shaped Virus	Reduced longevity by 1/3, especially in winter.	
Satellite Virus or Chronic Bee Paralysis Associate Virus	With CBPV.	Bailey 1975, 1981
Iridescent Virus/ Iridescent Bee Virus	*Apis cerana* color changes in internal organs. Infected colonies may die.	Bailey 1975, Anderson 1995
Rickettsial bodies including F Virus (folded filamentous) or Filamentous Virus	Sluggishness and inability to fly, milky haemolymph sometimes.	Clark 1977, Anderson 1995

It is important to realize that "symptoms" are only indicative that a certain pathogen may be present. Only through "diagnosis" can infection be confirmed.

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Table 2. The pathogens (viruses) and the transmitters (*Varroa* mite, *V. destructor)* found in European races of the Western honey bee (*Apis mellifera*) (*Am*) and the Asiatic Hive Bee (*Apis cerana*) (*Ac*) to cause diseases. The viruses are ABPV = Acute Bee Paralysis Virus; BQCV = Black Queen Cell Virus; BXV = Bee Virus X; BYV= Bee Virus Y; CBPV = Chronic Bee Paralysis Virus; CWV = Cloudy Wing Virus; DWV = Deformed Wing Virus; KBV = Kashmir Bee Virus; KV = Kakugo Virus; SBV = Sac Brood Virus; SBPV = Slow Bee Paralysis Virus; TSBV = Thai Sac Brood Virus. The interaction with *Varroa* is noted as positive by experimentation (+) or by implication (+ Imp). The mode or modes of transmission, and potential complications, are noted with V.

Host	Viruses	Interaction	Transmission	References
Am(USA)	ABPV, BQCV, CBPV, DWV, KBV, SBV	+	Vertical transmission	Chen et al. 2006
Am (Germany)	DWV	+	V+ Food	Yue & Genersch 2005
Am (USA)	KBV, DWV	+	V+ Immuno compromised	Shen et al. 2005a
Am (USA)	KBV, SBV	+	V+ transovarian, Food, Saliva	Shen et al. 2005b
Am (USA)	KBV, SBV	+	V+ Transovarian, Food, Saliva	Siede et al. 2005
Am (USA)	DWV	+	V+Immuno compromised	Yang & Cox-Foster 2005
Am (USA)	DWV	+ Imp		Chen et al. 2005
Am (France)	DWV, SBV,CBPV, ABPV,BQCV,KBV	+ Imp		Tentcheva et al. 2004
Am (Japan)	DWV,KV	+ Imp		Ongus et al. 2004
Am (USA)	KBV	+		Chen et al. 2004
Am (Sweden/UK)	General	+ Imp		Sumpter & Martin 2004
Am (USA)	DWV, SBV, KBV	+	V+ transovarian, Food	Shen 2003
Am (?)	DWV	+		Nordstrom 2003
Am (USA)	KBV		Fecal	Hung 2000
Am (Hungary)	ABPV	+ Imp		Bakonyi et al. 2002
Am (UK)	DWV	+		Martin 2001
Am (USA)	ABPV + KBV	no	Mites not invoked	Evans 2001
Am (Poland)	SBV	+	V	Jedruszuk 2000
In vitro	ABPV	+	V+ Food	Brodsgaard et al. 2000
Ac (Philippines & Nepal)	TSBV	+ Imp	V+ Infested drone brood cells	Boecking 1999
Am (Scandinavia)	CWV,DWV,ABPV,BQCV	+ Imp	V	Nordstrom et al. 1999
Am (Hungary)	APV	+	V	Bekesi et al. 1999
Am (USA)	DWV	+ Imp	V	Hung & Shimanuki 1999
Am (Hungary)	ABPV	+ Imp	V	Bekesi et al. 1999
Am (UK)	DWV	+	V	Bowen-Walker et al. 1999
Am (Poland)	FV,BQCV,BYV,ABPV,CBPV,SBV	+	V+ *Nosema apis*	Topolska et al. 1995
Am (France)	ABPV,CBPV,SBV	+	V+ Foraging bee	Faucon et al. 1992
Am (Fiji)	CBPV,SBV,BQCV,BXV, BYV,KBV, SBPV, DWV	+	*Nosema apis*, *Malpighamoeba mellificae*	Anderson 1990
Am (Yugoslavia)	ABPV,CWV,BQCV	+	V+*Nosema apis*	Kulincevic et al. 1990
Am (Netherlands, Germany, UK)	ABPV	+	V+Larval food	Ball & Allen 1988
Am (Europe)	ABPV	+	V	Bailey et al. 1979; Batuev 1979; Bailey, 1982 ; Ritter et al. 1984; Ball 1985; Ball & Allen 1988; Allen et al. 1986

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