



## The worldwide health status of honey bees

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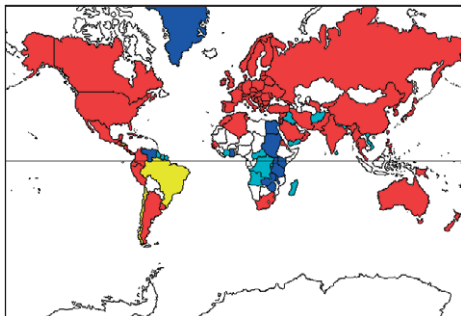


FIG. 1. The worldwide distribution of American foulbrood.

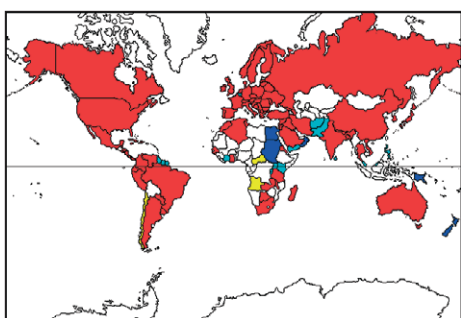


FIG. 2. The worldwide distribution of European foulbrood.

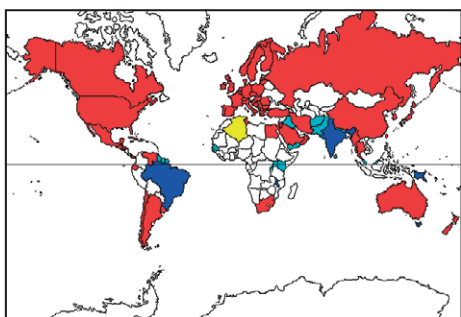


FIG. 3. The worldwide distribution of chalkbrood.

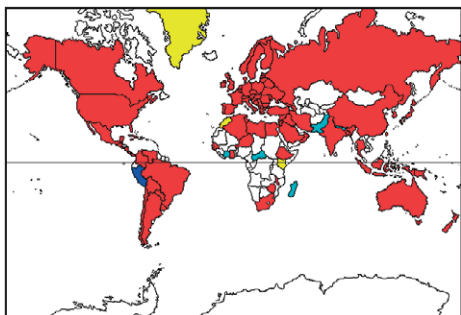


FIG. 4. The worldwide distribution of nosema disease.

# The worldwide health status of honey bees

JAMES D ELLIS and PAMELA A MUNN

In 1988, a comprehensive review of world bee health was published in *Bee World*. Intended as an accessible and reliable reference to worldwide bee health status, updates have been published at intervals since then, including one devoted to viruses. These reviews have proved a valuable and accurate source of information on worldwide bee health. The last was published 10 years ago and the long-awaited latest in the series is presented here.

## Introduction

Honey bees are among the most successful organisms on the planet. Able to survive a wide range of climates and environments, they now inhabit most areas of the world occupied by humans. Accompanying the spread of bees globally has been a host of bee pathogens, parasites, pests and viruses. Many of these organisms are only just beginning to be understood (small hive beetles (*Aethina tumida*) and many bee viruses), while others remain at the forefront of bee research (varroa (*Varroa destructor*) and American foulbrood (*Paenibacillus larvae*)).

Because of concerns associated with the global spread of bee diseases, Bradbear<sup>12</sup> and Matheson<sup>35,36,37</sup> published reviews on the

health status of honey bees internationally. These publications remain the best resources available for information on the worldwide distribution of diseases and pests of honey bees. In their reviews, they discussed the most prevalent/economically important pests and diseases of honey bees (table 1).

In 1996, Allen & Ball<sup>2</sup> published a similar review on the incidence and worldwide distribution of honey bee viruses. Prior to the 1980s, little was known about the existence of honey bee viruses. Recently, however, researchers have begun to study the effects of viruses on colony vigour and overall bee health. Many of these viruses are vectored by varroa<sup>2</sup> and their additive effects on bees remain uncertain. Indeed, varroa's popularity as a research topic has contributed to the

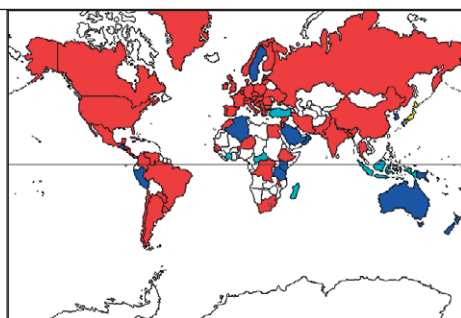
TABLE 1. Diseases, parasites and pests whose worldwide distributions are discussed in this review.

Common name	Causative organism	Corresponding figure no.
<b>Brood diseases</b>		
American foulbrood (AFB)	<i>Paenibacillus larvae larvae</i>	1
European foulbrood (EFB)	<i>Melissococcus plutonius</i>	2
Chalkbrood	<i>Ascosphaera apis</i>	3
<b>Adult diseases</b>		
Nosema disease	<i>Nosema apis</i>	4
Amoeba disease	<i>Malpighamoeba mellificae</i>	5
<b>Parasitic mites</b>		
Tracheal mite	<i>Acarapis woodi</i>	6
Varroa	<i>Varroa destructor</i>	7
Tropilaelaps	<i>Tropilaelaps clareae</i>	8
<b>Other</b>		
Braula (bee louse)	<i>Braula</i> spp.	9
Small hive beetle (SHB)*	<i>Aethina tumida</i>	10

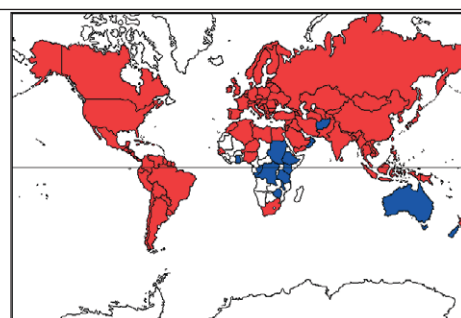
\*small hive beetles, responsible for aethinosis, were not discussed in Matheson's original reviews<sup>35,36,37</sup>



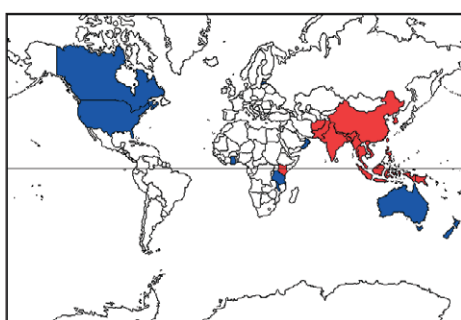
**FIG. 5.** The worldwide distribution of amoeba disease.



**FIG. 6.** The worldwide distribution of tracheal mites.



**FIG. 7.** The worldwide distribution of varroa mites.



**FIG. 8.** The worldwide distribution of tropilaelaps mites.



**FIG. 9.** The worldwide distribution of braula.



**FIG. 10.** The worldwide distribution of small hive beetles.

Common Host	Virus	Corresponding figure no.
<i>Apis mellifera</i>	Chronic paralysis (CPV)	11
	Chronic paralysis associate (CPVA)	12
	Cloudy wing (CWV)	13
	Acute paralysis (APV)	14
	Black queen cell (BQCV)(also detected in <i>A. florea</i> )	15
	Deformed wing/Egypt (DWW)	16
	Sacbrood (SBV)	17
	Kashmir - various strains (KBV)	18
	Slow paralysis (SPV)	19
	Bee virus X (BVX)	20
	Bee virus Y (BVY)	21
	Filamentous (FV)	22
<i>Apis cerana</i>	Deformed wing (DWW)	*
	Kashmir – Indian type strain (KBV)	*
	Thai sacbrood (TSBV) (also detected in <i>A. florea</i> and <i>A. dorsata</i> )	*
	<i>Apis iridescent</i> (AIV)	*

\*We did not include distribution figures for viruses of *Apis cerana*

Description of status	Symbol used in tables 4–13	Colour of Country	Criteria employed
Present	+	red	Reported in a peer-reviewed article, or an authoritative review or investigation; report by apparently reliable witness of a disease with recognizable field symptoms or using proper laboratory techniques.
Suspected present	+?	yellow	Anecdotal or hearsay report; field diagnosis of condition without obvious symptoms.
Suspected absent	-?	light blue	Limited investigation made with negative results; anecdotal reports about absence of disease with field symptoms.
Absent	-	blue	Rigorous survey carried out, laboratory analyses made where appropriate.
No information		white	No information available; anecdotal reports of the absence of asymptomatic condition.



FIG. 11. The worldwide distribution of chronic paralysis virus.



FIG. 12. The worldwide distribution of chronic paralysis virus associate.



FIG. 13. The worldwide distribution of cloudy wing virus.



FIG. 14. The worldwide distribution of acute paralysis virus.



FIG. 15. The worldwide distribution of black queen cell virus.



FIG. 16. The worldwide distribution of deformed wing virus.

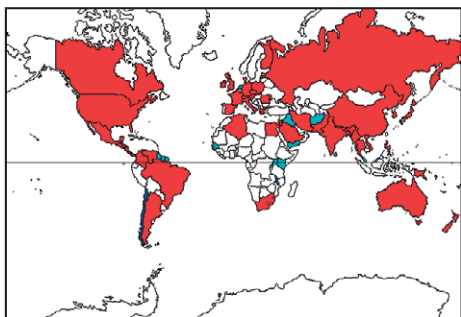


FIG. 17. The worldwide distribution of sacbrood virus.



FIG. 18. The worldwide distribution of Kashmir virus.



FIG. 19. The worldwide distribution of slow paralysis virus.



FIG. 20. The worldwide distribution of bee virus X.



FIG. 21. The worldwide distribution of bee virus Y.



FIG. 22. The worldwide distribution of filamentous virus.

**TABLE 4. Honey bee diseases and parasites in countries of the Americas. Numbers refer to entries in the list of references used to justify the bee health status given.**

Country	Brood diseases			Adult diseases		Parasitic mites			Other	
	AFB	EFB	chalkbrood	nosema	amoeba	tracheal	varroa	tropilaelaps	braula	SHB
<b>North America</b>										
Alaska (USA)	+ <sup>36</sup>	+ <sup>36</sup>	+ <sup>36</sup>	+ <sup>36</sup>		+ <sup>35</sup>	+ <sup>35</sup>			
Canada	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>	— <sup>35</sup>		
Mexico	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>		+ <sup>35</sup>	+ <sup>35</sup>		+ <sup>37</sup>	
USA (contiguous)	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>	— <sup>36</sup>	+ <sup>35</sup>	+ <sup>21</sup>
<b>Central America</b>										
Belize	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>		+ <sup>35</sup>	+ <sup>37</sup>		+ <sup>35</sup>	
Costa Rica	+ <sup>35</sup>	+ <sup>35</sup>		+ <sup>35</sup>	+ <sup>37</sup>	+ <sup>35</sup>	+ <sup>45</sup>		+ <sup>37</sup>	
El Salvador	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>		+ <sup>35</sup>	+ <sup>45</sup>			
Guatemala	+ <sup>35</sup>		+ <sup>37</sup>	+ <sup>45</sup>		— <sup>35</sup>	+ <sup>45</sup>			
Honduras	+ <sup>13</sup>	+ <sup>35</sup>	+ <sup>35</sup>			+ <sup>35</sup>	+ <sup>45</sup>			
Nicaragua	+ <sup>37</sup>	+ <sup>37</sup>		+ <sup>35</sup>		+ <sup>35</sup>	+ <sup>45</sup>			
Panama	+ <sup>35</sup>	+ <sup>36</sup>	+ <sup>37</sup>	+ <sup>35</sup>		+ <sup>35</sup>	+ <sup>45</sup>		+ <sup>35</sup>	
<b>Caribbean &amp; other islands</b>										
Antigua	— <sup>35</sup>	— <sup>35</sup>	— <sup>35</sup>							
Bahamas	+ <sup>35</sup>									
Barbados							+ <sup>45</sup>			
Bermuda	+ <sup>35</sup>	+ <sup>36</sup>	— <sup>35</sup>	+ <sup>35</sup>						
Cayman Islands							+ <sup>45</sup>			
Cuba	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>45</sup>		+ <sup>37</sup>	+ <sup>45</sup>			
Dominican Republic	+ <sup>35</sup>	+ <sup>45</sup>					+ <sup>45</sup>			
Dominica	— <sup>36</sup>	— <sup>36</sup>	— <sup>36</sup>				+ <sup>45</sup>			
Grenada	— <sup>36</sup>	— <sup>36</sup>	— <sup>36</sup>			+ <sup>36</sup>	+ <sup>36</sup>			
Guadeloupe		+ <sup>35</sup>		+ <sup>45</sup>		+ <sup>45</sup>	+ <sup>45</sup>			
Haiti	+ <sup>37</sup>	+ <sup>37</sup>				+ <sup>37</sup>				
Jamaica	+ <sup>35</sup>	+ <sup>45</sup>	— <sup>35</sup>	+ <sup>45</sup>		— <sup>35</sup>	+ <sup>45</sup>			*
Martinique	— <sup>35</sup>	— <sup>35</sup>	— <sup>35</sup>				+ <sup>45</sup>			
Netherlands Antilles							+ <sup>48</sup>			
Nevis	— <sup>35</sup>	— <sup>35</sup>	— <sup>35</sup>			+ <sup>45</sup>	+ <sup>45</sup>			
Puerto Rico			+ <sup>36</sup>			+ <sup>36</sup>	+ <sup>36</sup>			
St Lucia	— <sup>35</sup>	— <sup>35</sup>	— <sup>35</sup>							
St Vincent	+ <sup>36</sup>	+ <sup>45</sup>	— <sup>36</sup>			+ <sup>36</sup>	+ <sup>45</sup>			
Trinidad and Tobago	— <sup>35</sup>	+ <sup>37</sup>	— <sup>35</sup>				+ <sup>45</sup>		+ <sup>35</sup>	
<b>South America</b>										
Argentina	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>		+ <sup>35</sup>	
Bolivia				+ <sup>35</sup>			+ <sup>35</sup>		+ <sup>35</sup>	
Brazil	+ <sup>13</sup>	+ <sup>35</sup>	— <sup>36</sup>	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>		+ <sup>35</sup>	
Chile	+ <sup>45</sup>	+ <sup>35</sup>	+ <sup>49</sup>	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>36</sup>		+ <sup>35</sup>	
Columbia	+ <sup>35</sup>	+ <sup>35</sup>		+ <sup>35</sup>		+ <sup>35</sup>	+ <sup>37</sup>		+ <sup>35</sup>	
Ecuador	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>37</sup>				+ <sup>50</sup>			
French Guiana	— <sup>35</sup>	— <sup>35</sup>	— <sup>35</sup>				+ <sup>45</sup>			
Guyana	— <sup>35</sup>	— <sup>35</sup>	— <sup>35</sup>				+ <sup>50</sup>			
Paraguay		+ <sup>35</sup>		+ <sup>35</sup>		+ <sup>35</sup>	+ <sup>35</sup>		+ <sup>35</sup>	
Peru	+ <sup>36</sup>	+ <sup>35</sup>		— <sup>35</sup>		— <sup>35</sup>	+ <sup>35</sup>		+ <sup>35</sup>	
Surinam	— <sup>35</sup>	— <sup>35</sup>	— <sup>35</sup>				+ <sup>50</sup>			
Uruguay	+ <sup>37</sup>	+ <sup>35</sup>	+ <sup>28</sup>	+ <sup>35</sup>		+ <sup>35</sup>	+ <sup>35</sup>		+ <sup>35</sup>	
Venezuela	— <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>		+ <sup>35</sup>	

\*There are unpublished reports of small hive beetles in Jamaica.

**TABLE 5. Honey bee diseases and parasites in countries of Europe (including the former USSR). Numbers refer to entries in the list of references used to justify the bee health status given.**

Country	Brood diseases			Adult diseases		Parasitic mites			Other	
	AFB	EFB	chalkbrood	nosema	amoeba	tracheal	varroa	tropilaelaps	braula	SHB
Albania	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>36</sup>	+ <sup>35</sup>		+ <sup>35</sup>	+ <sup>35</sup>		+ <sup>35</sup>	
Andorra						+ <sup>7</sup> <sup>45</sup>	+ <sup>7</sup> <sup>45</sup>			
Austria	+ <sup>35</sup>	+ <sup>35</sup>		+ <sup>35</sup>		+ <sup>35</sup>	+ <sup>35</sup>		+ <sup>35</sup>	
Belgium	+ <sup>35</sup>	- <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>		+ <sup>35</sup>	
Bulgaria	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>24</sup>	+ <sup>35</sup>		+ <sup>35</sup>	+ <sup>35</sup>		+ <sup>35</sup>	
Corsica (France)						+ <sup>35</sup>				
Cyprus	+ <sup>35</sup>	+ <sup>35</sup>		+ <sup>37</sup>			+ <sup>35</sup>			
<b>Czechoslovakia (former)</b>	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>		+ <sup>35</sup>	
-Czech Republic	+ <sup>45</sup>	+ <sup>45</sup>				+ <sup>45</sup>	+ <sup>45</sup>			
-Slovakia	+ <sup>45</sup>	+ <sup>45</sup>	+ <sup>27</sup>	+ <sup>45</sup>			+ <sup>7</sup> <sup>45</sup>			
Denmark	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>36</sup>	+ <sup>35</sup>		+ <sup>35</sup>	
Finland	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>	- <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>		+ <sup>35</sup>	
France	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>		+ <sup>35</sup>	
Germany	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>		+ <sup>35</sup>	
Greece	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>		+ <sup>35</sup>	
Greenland	- <sup>13</sup>			+ <sup>7</sup> <sup>45</sup>		+ <sup>45</sup>				
Guernsey (UK)							+ <sup>36</sup>			
Hungary	+ <sup>35</sup>	+ <sup>36</sup>	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>		+ <sup>35</sup>	
Isle of Man (UK)				+ <sup>36</sup>						
Irish Republic	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>45</sup>		+ <sup>35</sup>	
Italy	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>		+ <sup>35</sup>	
Jersey (UK)							+ <sup>36</sup>			
Liechtenstein		+ <sup>45</sup>					+ <sup>45</sup>			
Luxembourg	+ <sup>35</sup>			+ <sup>35</sup>			+ <sup>35</sup>			
Majorca (Spain)						+ <sup>35</sup>				
Malta	+ <sup>35</sup>	+ <sup>35</sup>		+ <sup>35</sup>		+ <sup>35</sup>	+ <sup>36</sup>		+ <sup>7</sup> <sup>35</sup>	
Netherlands	+ <sup>35</sup>	+ <sup>45</sup>	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>		+ <sup>35</sup>	
Northern Ireland (UK)	+ <sup>35</sup>	+ <sup>35</sup>		+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>45</sup>		+ <sup>35</sup>	
Norway	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>	- <sup>35</sup>	+ <sup>45</sup>	+ <sup>35</sup>		+ <sup>35</sup>	
Poland	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>		+ <sup>35</sup>	
Portugal	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>		+ <sup>35</sup>	*
Romania	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>		+ <sup>35</sup>	
Sardinia (Italy)	+ <sup>35</sup>					+ <sup>35</sup>	+ <sup>35</sup>			
Sicily (Italy)							+ <sup>8</sup>			
Spain	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>	- <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>		+ <sup>36</sup>	
Sweden	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>36</sup>	+ <sup>35</sup>	+ <sup>36</sup>	- <sup>35</sup>	+ <sup>35</sup>		+ <sup>35</sup>	
Switzerland	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>			
United Kingdom	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>		+ <sup>36</sup>	
<b>USSR (former)</b>	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>		+ <sup>36</sup>	
-Armenia							+ <sup>45</sup>			
-Azerbaijan		+ <sup>45</sup>		+ <sup>45</sup>			+ <sup>45</sup>			
-Belarus	+ <sup>36</sup>	+ <sup>36</sup>		+ <sup>36</sup>			+ <sup>36</sup>			
-Estonia	+ <sup>36</sup>			+ <sup>36</sup>		+ <sup>36</sup>	+ <sup>36</sup>			
-Georgia	+ <sup>45</sup>	+ <sup>45</sup>		+ <sup>45</sup>			+ <sup>45</sup>			
-Kazakhstan							+ <sup>52</sup>			
-Krygyzstan	+ <sup>36</sup>						+ <sup>36</sup>			
-Latvia	+ <sup>36</sup>	+ <sup>36</sup>	+ <sup>36</sup>	+ <sup>36</sup>	- <sup>36</sup>	+ <sup>36</sup>	+ <sup>36</sup>	- <sup>36</sup>	+ <sup>36</sup>	
-Lithuania	+ <sup>45</sup>	+ <sup>36</sup>	+ <sup>62</sup>	+ <sup>36</sup>		+ <sup>45</sup>	+ <sup>36</sup>			
-Moldova	+ <sup>36</sup>	+ <sup>36</sup>		+ <sup>36</sup>			+ <sup>37</sup>			
-Russia	+ <sup>35</sup>	+ <sup>35</sup>		+ <sup>35</sup>		+ <sup>35</sup>	+ <sup>35</sup>			
-Tajikistan							+ <sup>50</sup>			
-Turkmenistan							+ <sup>50</sup>			
-Ukraine	+ <sup>36</sup>	+ <sup>36</sup>		+ <sup>36</sup>		+ <sup>45</sup>	+ <sup>36</sup>			
-Uzbekistan	+ <sup>37</sup>						+ <sup>37</sup>			

**TABLE 5. cont. Honey bee diseases and parasites in countries of Europe (including the former USSR). Numbers refer to entries in the list of references used to justify the bee health status given.**

Country	Brood diseases			Adult diseases		Parasitic mites			Other	
	AFB	EFB	chalkbrood	nosema	amoeba	tracheal	varroa	tropilaelaps	braula	SHB
<b>Yugoslavia (former)</b>	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>		+ <sup>35</sup>	
-Bosnia & Herzegovina	+ <sup>45</sup>			+ <sup>45</sup>					+ <sup>45</sup>	
-Croatia	+ <sup>36</sup>	+ <sup>36</sup>		+ <sup>36</sup>					+ <sup>36</sup>	
-Kosovo (Serbia & Montenegro)		+ <sup>45</sup>		+ <sup>45</sup>						
-Macedonia	+ <sup>45</sup>	+ <sup>45</sup>		+ <sup>45</sup>					+ <sup>45</sup>	
-Serbia & Montenegro (Yugoslavia)	+ <sup>45</sup>			+ <sup>45</sup>					+ <sup>45</sup>	
-Slovenia	+ <sup>36</sup>	+ <sup>45</sup>		+ <sup>36</sup>		+ <sup>37</sup>	+ <sup>36</sup>			

\*Small hive beetle larvae have been found in a queen cage shipped to Portugal from Texas, USA. The larvae were destroyed and there have been no further reports of the beetle in Europe.

understanding of some bee viruses. Viruses included in Allen & Ball<sup>2</sup> are presented in table 2.

Despite the usefulness of these reviews, it has been almost 10 years since their publication.<sup>2,35,36,37</sup> Since that time, many of the bee diseases, pests, parasites and viruses originally reviewed have been discovered in other countries. Additionally, geo-political boundaries have changed resulting in the formation of new countries or the renaming of old ones. Further, new pests (such as small hive beetles) have been identified and have begun their invasive spread around the world. It is for these reasons that we decided to update information on the status of honey bee health worldwide, consolidating current information on bee pathogens, parasites, pests, and viruses into one source. This review is an update of the original reports.<sup>2,35,36,37</sup> It is not meant to replace those reports but only supplement them where necessary and consolidate the information into a single source. We hope that this review will encourage further reporting of international bee health statuses, especially in countries for which such reports are deficient. We also discuss how humans have been instrumental in the spread of bee diseases, compromising bee health globally.

#### Usefulness and limits of this review

This review serves as a reference tool for those interested in the occurrence and possible spread of bee diseases/pests worldwide and in their own country. It must be noted that the spread of bee diseases should be inferred with discernment. That a disease has been recorded for the first time in a country not included in original reviews does not indicate the disease's spread to that country, only that the disease has been found in the country since an earlier review. We recognize our review is limited to the

'known' distribution of pests and diseases worldwide. We remain certain that many, if not most, of the reviewed pests/diseases occur in locations not mentioned in this review. Our discussion is limited to what we deem reliable, published information on disease presence in a country. A number of countries do not report such information in the literature.

Our mention of the suspected absence of a disease in a country does not preclude its presence there. A disease may be present in a country some time before its presence is discovered and subsequently published. That a disease/pest has been found in a country does not indicate it still occurs in that country; it could have been eradicated and no longer occur there. Similarly, the causative agent may be present in a country but not produce visible symptoms. An example of this occurs in South Africa where American foulbrood spores have been identified in honey but clinical symptoms of the disease never manifested.<sup>26</sup> Moreover, the fact that an entire country is highlighted on a distribution map (figs 1–22) does not mean the disease/pest occurs throughout the country. The pest may have a limited distribution within a country (see discussion).

Our review is also useful for those wanting to regulate the movement of bees and bee products around the world. The trade and movement of such items largely have been responsible for distributing most of the known pests and diseases. As such, the information we provide in our review may help limit future spread of diseases/pests; this is especially important in an increasingly global community. Our review is useful to those governing bodies responsible for monitoring the spread of animal diseases (for example the Office International des Épizooties (OIE)), especially for diseases/pests not deemed important in the past (i.e. viruses).

A major limitation of this and previous reviews on the international status of bee health lies with adequate diagnosis. Participants at a meeting of the honey bee disease branch of the OIE (Dublin, Ireland, August 2005) stressed the importance of adequate diagnosis of the major bee diseases/pests. One conclusion of the participants was that a number of diseases/pests have not been adequately diagnosed in the past. For example, field symptoms overlap for many diseases, and such symptoms are often used by some countries to determine the presence of a bee pathogen. Another example concerns the prolonged misidentification of the varroa mite which was until recently classified as *Varroa jacobsoni* and not *V. destructor*.<sup>6</sup> When reviewed in detail, it is unclear how erroneous diagnosis of bee pests and diseases would affect maps of their current distribution, but this certainly highlights the need for universally accepted diagnostic tools (a goal of the OIE).

#### Methodology

The review is divided into two main sections: (1) bee diseases/pests/parasites, and (2) bee viruses. For continuity, we include information on the same diseases/pests/parasites that Matheson included in his reviews,<sup>35,36,37</sup> with the addition of small hive beetles (responsible for aethinosis – our new term for the presence of and any colony depredation caused by small hive beetles). Concerning viruses, we review the distribution of those included in Allen & Ball.<sup>2</sup> Four other viruses have been isolated from *Apis mellifera* but they probably have a limited distribution in nature. Two of these, Arkansas bee virus (in Arkansas<sup>9</sup> and California, USA<sup>2</sup>) and Berkeley bee picornavirus (also in the USA<sup>41</sup>), and other minor viruses affecting *A. cerana* were discussed in Allen & Ball.<sup>2</sup> Limited

**TABLE 6. Honey bee diseases and parasites in countries of Africa. Numbers refer to entries in the list of references, used to justify the bee health status given.**

Country	Brood diseases			Adult diseases		Parasitic mites			Other	
	AFB	EFB	chalkbrood	nosema	amoeba	tracheal	varroa	tropilaelaps	braula	SHB
<b>North of the Sahara</b>										
Algeria	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>	— <sup>35</sup>	+ <sup>35</sup>		+ <sup>35</sup>	
Canary Islands (Spain)	— <sup>35</sup>		— <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>		+ <sup>35</sup>	
Egypt	— <sup>35</sup>	— <sup>35</sup>	+ <sup>36</sup>	+ <sup>35</sup>		+ <sup>35</sup>	+ <sup>35</sup>		+ <sup>35</sup>	+ <sup>39</sup>
Libya				+ <sup>35</sup>			+ <sup>35</sup>			
Morocco	+ <sup>35</sup>	+ <sup>35</sup>		+ <sup>35</sup>		+ <sup>35</sup>	+ <sup>35</sup>		+ <sup>35</sup>	
Tunisia	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>36</sup>	+ <sup>36</sup>			+ <sup>35</sup>			
<b>Sub-Saharan</b>										
Angola	— <sup>35</sup>	+ <sup>35</sup>							+ <sup>35</sup>	+ <sup>53</sup>
Botswana		+ <sup>35</sup>							+ <sup>35</sup>	+ <sup>47</sup>
Burundi	— <sup>36</sup>	— <sup>35</sup>							+ <sup>36</sup>	
Cape Verde							+ <sup>37</sup>			
Central African Republic	— <sup>35</sup>	+ <sup>35</sup>		— <sup>35</sup>		— <sup>35</sup>				+ <sup>30</sup>
Congo							— <sup>35</sup>		+ <sup>35</sup>	+ <sup>17</sup>
Democratic Republic of the Congo (Zaire)	— <sup>35</sup>					+ <sup>35</sup>	— <sup>35</sup>		+ <sup>35</sup>	+ <sup>20</sup>
Djibouti							+ <sup>45</sup>			
Ethiopia				+ <sup>35</sup>		+ <sup>35</sup>	— <sup>35</sup>		+ <sup>35</sup>	+ <sup>39</sup>
Eritrea	+ <sup>45</sup>	+ <sup>45</sup>								+ <sup>39</sup>
Gambia	+ <sup>13</sup>									
Ghana	— <sup>37</sup>	+ <sup>37</sup>		+ <sup>37</sup>			— <sup>35</sup>	— <sup>35</sup>	+ <sup>35</sup>	+ <sup>1</sup>
Guinea-Bissau	+ <sup>26</sup> *	+ <sup>35</sup>		+ <sup>36</sup>		+ <sup>36</sup>			+ <sup>35</sup>	+ <sup>60</sup>
Ivory Coast	— <sup>35</sup>	— <sup>35</sup>		— <sup>35</sup>		— <sup>35</sup>				
Kenya	— <sup>13</sup>	— <sup>35</sup>	— <sup>35</sup>	+ <sup>35</sup>		— <sup>35</sup>	— <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>39</sup>
Madagascar	— <sup>35</sup>	+ <sup>35</sup>		— <sup>35</sup>		— <sup>35</sup>				
Malawi	— <sup>35</sup>	+ <sup>35</sup>	— <sup>35</sup>	+ <sup>35</sup>	— <sup>35</sup>	+ <sup>35</sup>	— <sup>35</sup>	— <sup>35</sup>	+ <sup>35</sup>	
Mauritius	— <sup>35</sup>	— <sup>35</sup>	— <sup>35</sup>	+ <sup>35</sup>		— <sup>35</sup>			+ <sup>35</sup>	
Mozambique									+ <sup>35</sup>	
Namibia										+ <sup>39</sup>
Niger				+ <sup>35</sup>		+ <sup>35</sup>	+ <sup>35</sup>			
Nigeria							+ <sup>33</sup>			+ <sup>40</sup>
Reunion	— <sup>35</sup>	+ <sup>36</sup>	— <sup>35</sup>	+ <sup>35</sup>		+ <sup>35</sup>			— <sup>35</sup>	
Rwanda	— <sup>35</sup>	— <sup>35</sup>	— <sup>35</sup>						+ <sup>35</sup>	
Senegal	+ <sup>37</sup>	+ <sup>35</sup>	— <sup>35</sup>	+ <sup>37</sup>		+ <sup>37</sup>	+ <sup>37</sup>		+ <sup>35</sup>	+ <sup>41</sup>
Seychelles	— <sup>35</sup>	— <sup>35</sup>	— <sup>35</sup>						— <sup>35</sup>	
South Africa	+ <sup>26</sup> *	+ <sup>35</sup>	+ <sup>7</sup>	+ <sup>35</sup>	— <sup>35</sup>	+ <sup>37</sup>	+ <sup>61</sup>		+ <sup>35</sup>	+ <sup>32</sup>
Sudan	— <sup>35</sup>	— <sup>35</sup>					— <sup>35</sup>			
Swaziland							+ <sup>45</sup>			
Tanzania	— <sup>13</sup>	+ <sup>35</sup>				— <sup>35</sup>	— <sup>35</sup>	— <sup>35</sup>	+ <sup>35</sup>	+ <sup>44</sup>
Uganda	— <sup>13</sup>	— <sup>35</sup>	— <sup>35</sup>							+ <sup>51</sup>
Zambia	— <sup>35</sup>	+ <sup>35</sup>							+ <sup>35</sup>	+ <sup>18</sup>
Zimbabwe	— <sup>13</sup>			+ <sup>22</sup>	+ <sup>35</sup>		— <sup>35</sup>		+ <sup>35</sup>	+ <sup>54</sup>

\*found in honey but no colony symptoms

distributions from two additional viruses, Japan virus (in Iran<sup>38</sup>) and bee virus F (in Australia<sup>5</sup>), have been discussed in the literature.

Because of past discrepancies in diagnostic tests, our report employs the more stringent criteria for recording the status of a parasite or disease as outlined by Matheson.<sup>35,36,37</sup> An outline of our methodology for reporting pests and diseases is included in table 3. For

viruses, we only indicate the presence of a given virus in a country, not its absence, presumed absence, or presumed presence (except for sacbrood and Kashmir bee viruses which have been studied longer). In an attempt to remain consistent with previous reviews, we favoured positive laboratory diagnostic tests as opposed to field symptoms because of the unreliability of field symptoms alone (as stressed at the OIE conference in Dublin). This was easier for viruses than for

the other bee diseases/pests because positive identification of a virus involves qualitative laboratory tests, not subjective clinical observations of sick bees or colonies.

We report the absence of a particular disease with caution. In such instances, we favour widely-conducted field surveys followed by laboratory analyses. However, even in these instances we recognize that a disease/pest may be present in a country yet remain

undetected. Regarding positive and negative records, we avoided the simple 'observance' of a pest via verbal communication. We only include pest records which have been published in reliable sources. For ease of determining the validity of a given source, all records of disease absence/presence are given with a full reference. Where reviewed by Matheson<sup>35,36,37</sup> or Allen & Ball,<sup>2</sup> we reference the review and not the original source. If the original source is needed, it can be found in the referenced reviews.

A particular problem exists when referencing reports from defunct political entities. In the

cases of the former Czechoslovakia (the Czech Republic and Slovakia), the former Yugoslavia (Slovenia, Croatia, Bosnia and Herzegovina, Macedonia, and Yugoslavia (Kosovo, Serbia and Montenegro)), and the former USSR (Russia, Estonia, Latvia, Lithuania, Belarus, Ukraine, Moldova, Georgia, Armenia, Azerbaijan, Kazakhstan, Turkmenistan, Kyrgyzstan, Uzbekistan, and Tajikistan), disease status is reported for the newer independent states where possible and highlighted on the various distribution maps (figs 1–22). If not possible, disease status is reported for the parent country no longer in

existence, and the entire region is highlighted on the various distribution maps (figs. 1–22). In this circumstance, we recommend using the original reference for the disease status listed in Matheson<sup>35,36,37</sup> and Allen & Ball<sup>2</sup> in order to make personal decisions about the presence/absence of a particular disease/pest in the newer states.

Concerning both the former Czechoslovakia and Yugoslavia, bees and bee products moved freely between the now-independent republics so the presence of a disease/pest in one (ex. the Czech Republic) suggests its presence in another (ex. Slovakia). The same

**TABLE 7. Honey bee diseases and parasites in countries of Asia. Numbers refer to entries in the list of references used to justify the bee health status given.**

Country	Brood diseases			Adult diseases		Parasitic mites			Other	
	AFB	EFB	chalkbrood	nosema	amoeba	tracheal	varroa	tropilaelaps	braula	SHB
<b>Middle East</b>										
Iran	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>37</sup>	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>			+ <sup>35</sup>
Iraq	- <sup>35</sup>	+ <sup>35</sup>	- <sup>35</sup>	+ <sup>3</sup>			+ <sup>35</sup>			+ <sup>35</sup>
Israel	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>		+ <sup>36</sup>	+ <sup>35</sup>			+ <sup>35</sup>
Jordan	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>		+ <sup>4</sup>	+ <sup>35</sup>			+ <sup>35</sup>
Kuwait	+ <sup>45</sup>	+ <sup>45</sup>		+ <sup>45</sup>		+ <sup>45</sup>	+ <sup>45</sup>			
Lebanon	+ <sup>35</sup>	+ <sup>35</sup>		+ <sup>35</sup>		+ <sup>35</sup>	+ <sup>35</sup>			
Oman	+ <sup>35</sup>	- <sup>35</sup>	+ <sup>36</sup>	+ <sup>35</sup>		- <sup>35</sup>	- <sup>35</sup>	- <sup>35</sup>		+ <sup>35</sup>
Palestinian Auton. Territories						+ <sup>45</sup>	+ <sup>45</sup>			
Saudi Arabia	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>	- <sup>35</sup>	+ <sup>35</sup>			+ <sup>35</sup>
Syria	+ <sup>35</sup>	+ <sup>35</sup>		+ <sup>37</sup>		+ <sup>35</sup>	+ <sup>35</sup>			
Turkey	+ <sup>45</sup>	+ <sup>58</sup>	+ <sup>35</sup>	+ <sup>46,57</sup>		- <sup>16</sup>	+ <sup>35</sup>			+ <sup>35</sup>
United Arab Emirates							+ <sup>35</sup>			+ <sup>35</sup>
Yemen	- <sup>35</sup>	- <sup>35</sup>	- <sup>35</sup>				+ <sup>29</sup>			
<b>Indian subcontinent</b>										
Afghanistan	- <sup>35</sup>	- <sup>35</sup>	- <sup>35</sup>					- <sup>35</sup>		+ <sup>35</sup>
Bangladesh		+ <sup>35</sup>		+ <sup>35</sup>		+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>34</sup>		
Bhutan		+ <sup>35</sup>				+ <sup>35</sup>	+ <sup>50</sup>	+ <sup>35</sup>		
India	+ <sup>35</sup>	+ <sup>35</sup>	- <sup>35</sup>	+ <sup>35</sup>	- <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>		+ <sup>35</sup>
Nepal	- <sup>37</sup>	+ <sup>35</sup>	- <sup>37</sup>	- <sup>37</sup>	- <sup>37</sup>	+ <sup>37</sup>	+ <sup>35</sup>	+ <sup>35</sup>		
Pakistan	+ <sup>13</sup>	- <sup>35</sup>	- <sup>35</sup>	- <sup>35</sup>		+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>		
Sri Lanka	- <sup>35</sup>	- <sup>35</sup>	- <sup>35</sup>				+ <sup>35</sup>			+ <sup>36</sup>
<b>East of Indian subcontinent</b>										
Cambodia							+ <sup>35</sup>			
China	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>		+ <sup>35</sup>
Hong Kong	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>36</sup>	+ <sup>35</sup>		+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>		
Indonesia				+ <sup>36</sup>		- <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>		
Japan	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>45</sup>	- <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>			
Korea (N)	+ <sup>35</sup>						+ <sup>50</sup>			
Korea (S)	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>		- <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>		- <sup>35</sup>
Laos							+ <sup>35</sup>			
Malaysia	+ <sup>13</sup>	- <sup>35</sup>	- <sup>35</sup>				+ <sup>35</sup>	+ <sup>35</sup>		
Mongolia							+ <sup>35</sup>			
Myanmar (Burma)	+ <sup>35</sup>		+ <sup>35</sup>				+ <sup>35</sup>	+ <sup>35</sup>		
Philippines	+ <sup>35</sup>	- <sup>36</sup>					+ <sup>35</sup>	+ <sup>35</sup>		
Singapore							+ <sup>35</sup>			
Taiwan	+ <sup>35</sup>		+ <sup>35</sup>	+ <sup>35</sup>			+ <sup>35</sup>	+ <sup>35</sup>		
Thailand	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>		+ <sup>36</sup>	+ <sup>35</sup>	+ <sup>35</sup>		
Vietnam	- <sup>13</sup>	+ <sup>35</sup>					+ <sup>35</sup>	+ <sup>35</sup>		

**TABLE 8. Honey bee diseases and parasites in countries of Oceania (including Australia). Numbers refer to entries in the list of references used to justify the bee health status given.**

Country	Brood diseases			Adult diseases		Parasitic mites			Other	
	AFB	EFB	chalkbrood	nosema	amoeba	tracheal	varroa	tropilaelaps	braula	SHB
Australia (mainland)	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>	- <sup>35</sup>	- <sup>35</sup>	- <sup>35</sup>	- <sup>35</sup>	+ <sup>59</sup>
Cook Islands	+ <sup>35</sup>	- <sup>35</sup>	- <sup>35</sup>							
Fiji	+ <sup>35</sup>	- <sup>35</sup>	- <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>	- <sup>35</sup>	- <sup>35</sup>	- <sup>35</sup>		
French Polynesia	+ <sup>45</sup>	+ <sup>45</sup>								
Hawaii (USA)	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>		- <sup>35</sup>	- <sup>35</sup>	- <sup>36</sup>	- <sup>36</sup>	
New Caledonia (France)	+ <sup>35</sup>	+ <sup>35</sup>		+ <sup>35</sup>	- <sup>35</sup>	- <sup>35</sup>	- <sup>35</sup>			
New Zealand	+ <sup>35</sup>	- <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>	- <sup>35</sup>	+ <sup>45</sup>	- <sup>35</sup>	- <sup>35</sup>	
Niue	+ <sup>35</sup>	- <sup>35</sup>		+ <sup>35</sup>		- <sup>35</sup>	- <sup>35</sup>	- <sup>35</sup>		
Norfolk Island (Australia)	- <sup>35</sup>	- <sup>35</sup>	- <sup>35</sup>	+ <sup>35</sup>	- <sup>35</sup>	- <sup>35</sup>	- <sup>35</sup>	- <sup>35</sup>	- <sup>35</sup>	
Palau	- <sup>37</sup>	- <sup>37</sup>	- <sup>37</sup>							
Papua New Guinea	+ <sup>35</sup>	- <sup>35</sup>	- <sup>35</sup>	+ <sup>35</sup>		- <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>		
Solomon Islands	- <sup>35</sup>	- <sup>35</sup>	- <sup>35</sup>	+ <sup>35</sup>		- <sup>35</sup>	- <sup>35</sup>	- <sup>35</sup>		
Tasmania (Australia)	+ <sup>35</sup>	+ <sup>35</sup>	- <sup>35</sup>	+ <sup>35</sup>		- <sup>35</sup>	- <sup>35</sup>	- <sup>35</sup>	+ <sup>35</sup>	
Tonga	+ <sup>35</sup>	- <sup>35</sup>	- <sup>35</sup>	+ <sup>35</sup>	- <sup>35</sup>	- <sup>35</sup>	- <sup>35</sup>	- <sup>35</sup>	- <sup>35</sup>	
Torres Strait (Australia)							+ <sup>37</sup>			
Tuvalu	- <sup>35</sup>	- <sup>35</sup>	- <sup>35</sup>			- <sup>35</sup>	- <sup>35</sup>	- <sup>35</sup>	- <sup>35</sup>	
Vanuatu	+ <sup>45</sup>	- <sup>35</sup>	- <sup>35</sup>	+ <sup>45</sup>			- <sup>35</sup>	- <sup>35</sup>	- <sup>35</sup>	
Western Samoa	- <sup>35</sup>	- <sup>35</sup>	+ <sup>35</sup>	+ <sup>35</sup>	- <sup>35</sup>	- <sup>35</sup>	- <sup>35</sup>	- <sup>35</sup>	- <sup>35</sup>	

is not true for the former USSR due to its size and range of climates and ecological conditions.<sup>35</sup> We dealt with this issue as conservatively as possible. When no information is given for the newer states, the entire former territory is highlighted in the various figures. When information is given for the newer states, only those states are highlighted. For this reason, distribution maps in our review may show fewer countries for a given pest/disease than shown by maps of Matheson.<sup>35</sup>

Due to size constraints, it was not possible to show all countries on the distribution maps. However, data for each country for which there is information are included in the tables. Countries for which no information has been collected do not appear in the tables. As per Matheson,<sup>35</sup> names given to countries are the commonly used English-language forms. The representation of a state or territory is done for illustrative purposes only; we make no judgment about the political status of an area.<sup>35</sup>

Because of the quality of the more recent distribution reviews,<sup>2,35,36,37</sup> we searched relevant literature from 1994 to present. This was largely done using two sources: (1) *Apicultural Abstracts* (published by the International Bee Research Association), and (2) *World Animal Health Report 2004* (published by OIE).<sup>45</sup> These two sources proved invaluable in this exercise. Despite its usefulness, there were instances when

information in the OIE manual differed from that of published material. Further, we were often unable to obtain references or contact authors listed in *Apicultural Abstracts*. In both examples, new information concerning bee health status had to be omitted from this review in an effort to remain conservative. It is our feeling that these inconsistencies will be fixed in the future.

## Discussion

### General

It is important for all countries to conduct thorough surveys of disease presence within their respective boundaries and to document the location of various diseases/pests within their countries. Our review only discusses disease presence at the country level but would be more useful if within-country information were included. This would allow one to make better distribution maps and possibly limit the spread of noxious agents further. Small hive beetles in the USA provide a good model for this assertion as their invasion in that country is not complete.

To date, the beetle has been discovered in the following states (year of discovery in parentheses): Florida, South Carolina, Georgia and North Carolina (all 1998), New Jersey, Maine, Pennsylvania, Minnesota, Iowa, Wisconsin, Massachusetts, Ohio and Michigan (all 1999), Louisiana, New York, North Dakota, Tennessee, Indiana and Vermont (all

2000), Maryland, Virginia, Delaware, Illinois, Missouri, Mississippi (all 2001), Arkansas, Alabama, Kentucky (all 2002), West Virginia (2003) and Texas (2004)(J Pettis, USDA-ARS, personal communication). This information is useful because intra-national movement of bees could be regulated only for those areas with the target pest. A similar situation holds for Australia where the beetle is limited to parts of Queensland, New South Wales and Victoria (T Weatherhead, personal communication). In both countries, the beetles have limited spread through flight but abundant spread through the transportation of bees.

Beetle larvae have been found in Portugal on a queen cage from Texas, USA (anecdotal reports from various governmental and news sources). The larvae were destroyed, but this incursion could have been averted with more detailed information on the beetle's range in the USA. Likewise, anecdotal evidence suggests the beetle is also in Jamaica, but with no published information we could not include this in our review. This scenario holds true for a number of pests/diseases, strengthening the argument for the need of updated information on the status of diseases within countries.

It is our intention that this review will help limit the spread of pests/diseases around the world, not just for the sake of the host, but for other hosts on which some pests may prove extremely detrimental. Varroa remain a

TABLE 9. The world distribution of viruses in honey bees in the Americas.

Country	Virus											
	CPV	CPVA	CWV	APV	BQCV	DWV	SBV	KBV	SPV	BVX	BVY	FV
<b>North America</b>												
Canada	+ <sup>2</sup>		+ <sup>2</sup>		+ <sup>2</sup>		+ <sup>35</sup>	+ <sup>2</sup>	+ <sup>55</sup>	+ <sup>2</sup>	+ <sup>2</sup>	
Mexico	+ <sup>2</sup>						+ <sup>35</sup>					
USA (contiguous states)	+ <sup>2</sup>		+ <sup>2</sup>	+ <sup>2</sup>	+ <sup>2</sup>	+ <sup>65</sup>	+ <sup>35</sup>	+ <sup>2</sup>			+ <sup>2</sup>	+ <sup>2</sup>
<b>Central and South America and Caribbean</b>												
Argentina			+ <sup>2</sup>				+ <sup>2</sup>			+ <sup>2</sup>		
Antigua							— <sup>35</sup>					
Belize				+ <sup>2</sup>	+ <sup>2</sup>		+ <sup>35</sup>					
Brazil				+ <sup>2</sup>			+ <sup>35</sup>				+ <sup>2</sup>	
Chile							— <sup>35</sup>					
Columbia							+ <sup>35</sup>					
Costa Rica						+ <sup>15</sup>	+ <sup>37</sup>	+ <sup>19</sup>				
Dominica							— <sup>36</sup>					
French Guiana							— <sup>35</sup>					
Grenada							— <sup>36</sup>					
Guatemala							+ <sup>37</sup>					
Guyana							— <sup>35</sup>					
Honduras							+ <sup>35</sup>					
Jamaica							— <sup>35</sup>					
Martinique							— <sup>35</sup>					
Nevis							— <sup>35</sup>					
Nicaragua				+ <sup>2</sup>			+ <sup>37</sup>					
Panama							+ <sup>37</sup>					
St Lucia							— <sup>35</sup>					
St Vincent							— <sup>36</sup>					
Surinam							— <sup>35</sup>					
Trinidad and Tobago							+ <sup>35</sup>					
Venezuela							+ <sup>35</sup>					

classic example for this, displaying a host shift from *A. cerana* to *A. mellifera*. This host shift has resulted in worldwide losses of colonies of honey bees. Viruses associated with varroa may also prove detrimental when passed through non-natural hosts. There probably remain a suite of unidentified pests/diseases that could be included in health updates in the future. We hope that this review will help limit the spread of such diseases as well. In both instances, we cannot stress enough the importance of reliable, accurate diagnostic techniques.

#### Diseases, pests and parasites

With the exception of small hive beetles and tropilaelaps, most bee diseases, pests and parasites we report are nearly cosmopolitan in distribution (figs 1–10). In reality, they may be cosmopolitan, just not reported yet in those countries recording no information. Likewise, areas reporting the absence of a disease/pest often are bordered by countries recording the presence of the same disease/pest. Haiti, for example, records the presence of American foulbrood while the Dominican Republic reports its suspected absence. Both countries occupy the same

island and it is unlikely that, due to the ease of transmission of the causative agent, the disease has not spread over the entire island.

Another reason we suspect the near-cosmopolitan distribution of many of the diseases/pests we report is that, in general, only two areas of the world (Africa and countries formerly belonging to the USSR) report little or no information on bee health. Concerning Africa, those countries vigilantly reporting bee health (South Africa, Algeria, etc.) record the presence of most of the diseases/pests.

This leads one to believe that if thorough surveys were conducted throughout the rest of Africa, one might find that many of the diseases/pests occur over most of the continent. Further, most of the bee diseases/pests do not have the same economic importance everywhere in the world. This suggests that if a disease/pest (such as amoeba disease) causes few problems in an area, it is very likely to go undetected and unreported.

That most of the diseases/pest are nearly cosmopolitan in distribution contributes to the decline of bee health worldwide. For

example, bee health in the USA (where all reviewed diseases/pests, except tropilaelaps, are present) is at an all time low. This scenario occurs elsewhere across the globe as well. Needless to say, poor bee health is potentially disastrous for agriculture because of inadequate pollination and loss of honey bees as pollinators.

#### Viruses

Viruses do not appear to be as widespread globally as do bee diseases, pests and parasites. This could be due to two primary reasons: (1) either most of the viruses truly are limited in distribution, or (2) countries have had insufficient time and/or resources to adequately sample for the presence of viruses within their borders. Although possibly a combination of both reasons, it is more likely that many of the viruses do occur in countries for which we found no records but that adequate sampling has not been conducted to determine this.

Because many of the reviewed viruses are vectored or mechanically transmitted by varroa, it is safe to assume that their distribution is greater than what we report in this review, especially since varroa are nearly

TABLE 10. The world distribution of viruses in honey bees in Europe (including the former USSR).

Country	Virus											
	CPV	CPVA	CWV	APV	BQCV	DWV	SBV	KBV	SPV	BVX	BVY	FV
<b>Europe</b>												
Austria	+ <sup>2</sup>			+ <sup>11</sup>			+ <sup>25</sup>	-? <sup>56</sup>				
Belgium			+ <sup>2</sup>			+ <sup>2</sup>						
Bulgaria						+ <sup>2</sup>						
Cyprus				+ <sup>2</sup>	+ <sup>2</sup>	+ <sup>2</sup>	+ <sup>2</sup>					
<b>Czechoslovakia (former)</b>			+ <sup>2</sup>	+ <sup>2</sup>			+ <sup>35</sup>					
Denmark			+ <sup>43</sup>	+ <sup>43</sup>	+ <sup>43</sup>	+ <sup>2</sup>	+ <sup>35</sup>			+ <sup>2</sup>	+ <sup>2</sup>	
Finland			+ <sup>2</sup>				+ <sup>35</sup>				+ <sup>2</sup>	+ <sup>2</sup>
France	+ <sup>2</sup>		+ <sup>2</sup>	+ <sup>2</sup>	+ <sup>2</sup>	+ <sup>2</sup>	+ <sup>35</sup>	+ <sup>23</sup>		+ <sup>2</sup>	+ <sup>2</sup>	
Germany	+ <sup>2</sup>		+ <sup>2</sup>	+ <sup>2</sup>	+ <sup>2</sup>	+ <sup>2</sup>	+ <sup>25</sup>	+ <sup>7</sup>		+ <sup>2</sup>	+ <sup>2</sup>	+ <sup>2</sup>
Greece	+ <sup>2</sup>		+ <sup>2</sup>	+ <sup>2</sup>	+ <sup>2</sup>	+ <sup>2</sup>	+ <sup>35</sup>			+ <sup>2</sup>	+ <sup>2</sup>	+ <sup>2</sup>
Hungary				+ <sup>10</sup>				-? <sup>56</sup>				
Irish Republic	+ <sup>2</sup>		+ <sup>2</sup>				+ <sup>35</sup>					
Italy	+ <sup>2</sup>	+ <sup>2</sup>	+ <sup>2</sup>	+ <sup>2</sup>	+ <sup>2</sup>	+ <sup>2</sup>	+ <sup>35</sup>					+ <sup>2</sup>
Jersey, UK			+ <sup>2</sup>								+ <sup>2</sup>	
Luxembourg								+ <sup>56</sup>				
Malta	+ <sup>2</sup>											
Netherlands			+ <sup>2</sup>	+ <sup>2</sup>	+ <sup>2</sup>	+ <sup>2</sup>	-? <sup>35</sup>			+ <sup>2</sup>	+ <sup>2</sup>	+ <sup>2</sup>
Northern Ireland, UK							+ <sup>35</sup>					
Norway	+ <sup>2</sup>		+ <sup>43</sup>									
Poland	+ <sup>2</sup>	+ <sup>2</sup>		+ <sup>2</sup>	+ <sup>2</sup>	+ <sup>2</sup>	+ <sup>35</sup>	-? <sup>56</sup>			+ <sup>2</sup>	+ <sup>2</sup>
Portugal	+ <sup>2</sup>		+ <sup>2</sup>	+ <sup>2</sup>								
Romania	+ <sup>2</sup>		+ <sup>2</sup>	+ <sup>2</sup>	+ <sup>2</sup>	+ <sup>2</sup>	+ <sup>35</sup>			+ <sup>2</sup>		+ <sup>2</sup>
Spain	+ <sup>2</sup>		+ <sup>2</sup>			+ <sup>2</sup>	+ <sup>35</sup>	+ <sup>2</sup>		+ <sup>2</sup>		
Sweden			+ <sup>43</sup>	+ <sup>42</sup>		+ <sup>43</sup>						
Switzerland	+ <sup>2</sup>		+ <sup>2</sup>	+ <sup>2</sup>		+ <sup>2</sup>	+ <sup>35</sup>			+ <sup>2</sup>		
United Kingdom	+ <sup>2</sup>	+ <sup>2</sup>	+ <sup>2</sup>	+ <sup>2</sup>	+ <sup>2</sup>	+ <sup>2</sup>	+ <sup>35</sup>		+ <sup>2</sup>	+ <sup>2</sup>	+ <sup>2</sup>	+ <sup>2</sup>
<b>USSR (former)</b>							+ <sup>35</sup>					
-Armenia						+ <sup>2</sup>						
-Belorussia							+ <sup>2</sup>					+ <sup>2</sup>
-Kazakhstan	+ <sup>2</sup>											
-Latvia							+ <sup>36</sup>					+ <sup>2</sup>
-Moldavia	+ <sup>2</sup>					+ <sup>2</sup>	+ <sup>2</sup>					+ <sup>2</sup>
-Russia	+ <sup>2</sup>			+ <sup>2</sup>		+ <sup>2</sup>	+ <sup>2</sup>					+ <sup>2</sup>
-Tadjikistan						+ <sup>2</sup>						
-Turkmenia						+ <sup>2</sup>						
-Ukraine	+ <sup>2</sup>			+ <sup>2</sup>								+ <sup>2</sup>
<b>Yugoslavia (former)</b>			+ <sup>2</sup>	+ <sup>2</sup>	+ <sup>2</sup>	+ <sup>2</sup>					+ <sup>2</sup>	+ <sup>2</sup>
-Slovenia								-? <sup>56</sup>				

cosmopolitan. We do not mean to infer that bee viruses are present only in countries where varroa occur (varroa-free Australia has a number of bee viruses), only that virus distribution is greater than what we report due in part to varroa. The same may be true of bee viruses often associated with other pests/diseases such as nosema (*Nosema apis*). For example, Allen & Ball<sup>2</sup> suggest that chronic paralysis virus associate is likely present everywhere chronic paralysis virus occurs, despite that their distribution maps do not mirror one another (figs 11 and 12).

Sacbrood virus, which manifests symptoms reliable enough for confident diagnosis in the field, is probably the most studied of the bee

viruses. Consequently, its worldwide distribution is better known. Resulting from this is a worldwide distribution map for sacbrood (fig. 17) that is similar to distribution maps of the more widespread diseases/pests (figs 1–10). This may suggest that viruses harder to diagnose probably have a greater distribution than what we report. Regardless, there are some viruses (slow paralysis virus, for example) that appear to have a very limited distribution although this may be due to difficulties in detection.<sup>2</sup>

### Conclusions

This review highlights the relatively poor job we have done at limiting the spread of bee

diseases/pests globally. In fact, current disease/pest distributions probably are limited more by climatic/environmental factors than our efforts to stop their spread. Yet, it remains a 'call-to-arms' concerning those diseases/pests that currently have a limited worldwide distribution because it is not too late to stop potentially detrimental situations. We must be prudent when considering the shipment of bees and bee products internationally or when introducing bees into an area where they are not indigenous.

We do not take lightly the primary reason for the nearly worldwide distribution of many of the bee diseases/pests/viruses. Without doubt, humans have been the principal source

TABLE 11. The world distribution of viruses in honey bees in Africa, the Middle East, Asia, and Oceania.

Country	Virus											
	CPV	CPVA	CWV	APV	BQCV	DWV	SBV	KBV	SPV	BVX	BVY	FV
<b>Africa and the Middle East</b>												
Algeria							+ <sup>35</sup>					
Canary Islands (Spain)	+ <sup>2</sup>	+ <sup>2</sup>	+ <sup>2</sup>	+ <sup>2</sup>		+ <sup>2</sup>					+ <sup>2</sup>	
Egypt	+ <sup>2</sup>	+ <sup>2</sup>	+ <sup>2</sup>		+ <sup>2</sup>	+ <sup>2</sup>	+ <sup>35</sup>					
Iran			+ <sup>2</sup>	+ <sup>2</sup>	+ <sup>2</sup>	+ <sup>2</sup>	+ <sup>35</sup>			+ <sup>2</sup>	+ <sup>2</sup>	+ <sup>2</sup>
Iraq	+ <sup>2</sup>	+ <sup>2</sup>			+ <sup>2</sup>		- <sup>35</sup>				+ <sup>2</sup>	+ <sup>2</sup>
Israel	+ <sup>2</sup>	+ <sup>2</sup>		+ <sup>2</sup>	+ <sup>2</sup>		+ <sup>2</sup>					
Jordan							+ <sup>35</sup>					
Kenya							- <sup>35</sup>					
Malawi							- <sup>35</sup>					
Mauritius							- <sup>35</sup>					
Oman	+ <sup>2</sup>				+ <sup>2</sup>							
Reunion							- <sup>35</sup>					
Rwanda							- <sup>35</sup>					
Saudi Arabia	+ <sup>2</sup>				+ <sup>2</sup>	+ <sup>2</sup>	+ <sup>35</sup>				+ <sup>2</sup>	
Senegal							- <sup>35</sup>					
Seychelles							- <sup>35</sup>					
South Africa	+ <sup>2</sup>			+ <sup>19</sup>	+ <sup>2</sup>	+ <sup>2</sup>	+ <sup>35</sup>					+ <sup>2</sup>
Tunisia						+ <sup>2</sup>						
Uganda							- <sup>35</sup>					
Yemen					+ <sup>2</sup>		- <sup>35</sup>					+ <sup>2</sup>
<b>Asia</b>												
Afghanistan							- <sup>35</sup>					
Bangladesh							+ <sup>35</sup>					
China	+ <sup>2</sup>		+ <sup>2</sup>	+ <sup>2</sup>		+ <sup>2</sup>	+ <sup>35</sup>				+ <sup>2</sup>	
Hong Kong	+ <sup>2</sup>											
India							+ <sup>35</sup>					
Japan						+ <sup>2</sup>	+ <sup>63</sup>					+ <sup>2</sup>
Malaysia							- <sup>35</sup>					
Myanmar (Burma)							+ <sup>35</sup>					
Nepal						+ <sup>2</sup>	+ <sup>35</sup>					
Pakistan			+ <sup>2</sup>		+ <sup>2</sup>	+ <sup>2</sup>	+ <sup>2</sup>				+ <sup>2</sup>	
Philippines							+ <sup>35</sup>					
Korea (S)						+ <sup>2</sup>	+ <sup>35</sup>					
Sri Lanka							- <sup>35</sup>					
Thailand							+ <sup>35</sup>					
Vietnam							+ <sup>35</sup>					
<b>Oceania</b>												
Australia	+ <sup>2</sup>	+ <sup>2</sup>	+ <sup>2</sup>		+ <sup>2</sup>		+ <sup>35</sup>	+ <sup>2</sup>		+ <sup>2</sup>	+ <sup>2</sup>	+ <sup>2</sup>
Cook Islands							+ <sup>35</sup>					
Fiji	+ <sup>2</sup>				+ <sup>2</sup>		+ <sup>35</sup>	+ <sup>2</sup>	+ <sup>2</sup>	+ <sup>2</sup>	+ <sup>2</sup>	
Hawaii (USA)							+ <sup>35</sup>					+ <sup>2</sup>
New Zealand	+ <sup>2</sup>	+ <sup>2</sup>	+ <sup>2</sup>		+ <sup>2</sup>		+ <sup>35</sup>	+ <sup>2</sup>	+ <sup>64</sup>	+ <sup>2</sup>	+ <sup>2</sup>	+ <sup>2</sup>
Niue							+ <sup>35</sup>					
Norfolk Island (Australia)	+ <sup>2</sup>						- <sup>35</sup>					
Palau							- <sup>37</sup>					
Papua New Guinea	+ <sup>2</sup>				+ <sup>2</sup>		+ <sup>35</sup>	+ <sup>2</sup>				
Solomon Islands							+ <sup>35</sup>	+ <sup>2</sup>				
Tasmania (Australia)							+ <sup>35</sup>					
Tonga							+ <sup>2</sup>					
Vanuatu							- <sup>35</sup>					
Western Samoa	+ <sup>2</sup>						+ <sup>35</sup>		+ <sup>2</sup>			

TABLE 12. The world distribution of viruses in *Apis cerana*.

Country	Virus			
	DWV	KBV	TSBV	AIV
Bangladesh			+	
Bhutan			+	
China	+		+	
India		+	+	+
Myanmar (Burma)			+	
Nepal			+	
Pakistan			+	+
Papua New Guinea		+		
Thailand			+	
Vietnam			+	

TABLE 13. The world distribution of viruses in *Apis florea* and *Apis dorsata*.

Country	Viruses in <i>Apis florea</i>		Viruses in <i>Apis dorsata</i>
	BQCV	TSBV	TSBV
Iran	+		
India		+	+

facilitating the spread of bee diseases globally. Through unregulated trade of bees and bee products and often a lacklustre concern for established regulations, humans have made cosmopolitan many bee diseases that were originally limited in distribution. As a result of this and the chemicals we use to treat colonies for various diseases, bee health in many countries has been severely compromised. Some researchers speculate the beginning of a pollination crisis,<sup>14</sup> a crisis that ultimately may not be remedied easily. We hope that our review will bring this mounting crisis to the forefront of international attention.

In an effort to keep the world health status of bees updated, we invite collaborators to send us information regarding the presence/absence of a disease/pest in one's country. Although we have tried to make our review as accurate as possible, we recognize that there will be inaccuracies and omissions. For this reason, we invite your comments and new records, especially with published documentation. In conclusion, we hope that this review will further stimulate interest in the health status of honey bees worldwide.

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