

# NATIONAL MUSHROOM VIRUS SURVEY

By **Warwick Gill**, Tasmanian Institute of Agriculture, University of Tasmania, Hobart

**Judy Allan**, Pest and Disease Service

**The vast majority of mycoviruses – the viruses which are naturally widespread throughout both cultivated and wild fungi – cause no problems to their host. But occasionally, combinations of virus particles interact, causing quality and yield issues.**

Pathogenic viruses can be hard to detect in mushroom crops. They can replicate unseen and undetected, establishing large disease reservoirs on-farm. Early symptoms can go unnoticed or be ignored. For example, sporadic brown mushrooms appearing in white button crops being dismissed as just 'one of those things'.

The delay in identifying the causal 'organisms' was one of the key factors leading to the devastating impacts of Mushroom Virus X (MVX) Syndrome in Europe. Early detection and appropriate intervention is key to successfully mitigating the effects of these serious pathogens.

Australia has a long history of virus disease. La France was first recorded in this country in 1969 and there have been sporadic but damaging outbreaks recorded over the years.

In 2021 a farm reported a disorder expressing La France-like symptomology. However, samples sent to an external diagnostic laboratory did not detect the La France virus. A second sample was tested for MVX Syndrome viruses. This test detected the AbV6 virus particle, which is associated with MVX Syndrome.

A preliminary survey of mushrooms from supermarkets, together with selected farm samples, provided results consistent with the findings from the farm outbreak samples. After consultation with Dr Helen Grogan (Teagasc in Ireland, the leading authority on MVX Syndrome), and discussions with the MU16003 project reference group, it was decided to offer a nation-wide survey to the industry to determine the extent of virus contamination in Australian button mushroom crops.

## MUSHROOM VIRUS DISEASES

There are three recognised virus diseases of cultivated button mushrooms (summarised in Fig. 1) which result in yield and/or quality loss:

### 1. La France disease

- Symptoms include slow mycelial growth and distorted mushrooms as well as delayed, or reduced fruitbody emergence
- Caused by virus AbV1

### 2. Patch disease

- Resembles La France disease
- Results in major yield loss due to non-productive areas on the bed and misshapen mushrooms

- Virus AbV1 is absent
- Likely to be caused by virus AbVE1

### 3. Brown Cap Mushroom disease (BCMD)

- Expresses as fruitbody cap browning, causing significant reduction in quality
- Caused by virus AbV16

Viral mushroom diseases are not caused by one single virus in isolation. Both the pathogenic virus particle, and an auxiliary virus particle, need to be present to cause symptom expression. For La France, AbV1 interacts with mushroom bacilliform virus (MBV), while BCMD requires both AbV16 and AbV6 to be present to be pathogenic.

The situation is less clear for Patch disease, as only AbV6 has been identified. It is thought the second virus may be an endornavirus (type of virus that lacks a coat protein), AbVE1.

For all three viral mushroom diseases, both virus particles must be present before symptoms are expressed. The relative ratio of each virus type determines the severity of symptom expression in a synergistic interaction.

Until very recently, Patch disease and BCMD were thought to be one single disease – MVX. However, they are now considered to be distinct pathologies which have virus particle AbV6 in common.

MVX is sometimes referred to as 'MVX Complex' or 'MVX Syndrome' in recognition of this disease duality, but – confusingly – the label MVX has recently been applied to describe Patch disease only. To avoid misunderstanding, we will continue to refer to BCMD and Patch disease as separate and distinct diseases.

### THE SURVEY

The nation-wide industry virus survey was launched in December 2021. Farms were invited to participate through the Australian Mushrooms Journal. The testing was managed by the **MU16003** project team with the assistance of Crop Health Services Victoria (CHS), who offered discount diagnostic services to industry. As costs were met through the project, farms had the opportunity to have their crops virus-tested for free.

Participating farms were sent a unique and confidential farm code, a link to a virus symptom recognition video, a set of sampling and dispatch instructions and a sample submission form. Results were communicated back to the farms via Judy Allan (the survey coordinator), who also helped farms with a positive result to develop an action plan.

### THE SURVEY RESULTS

Virus survey results from the six participating farms (Table 1) were consistent with previously reported survey data from farm and supermarket samples (Allan 2021).

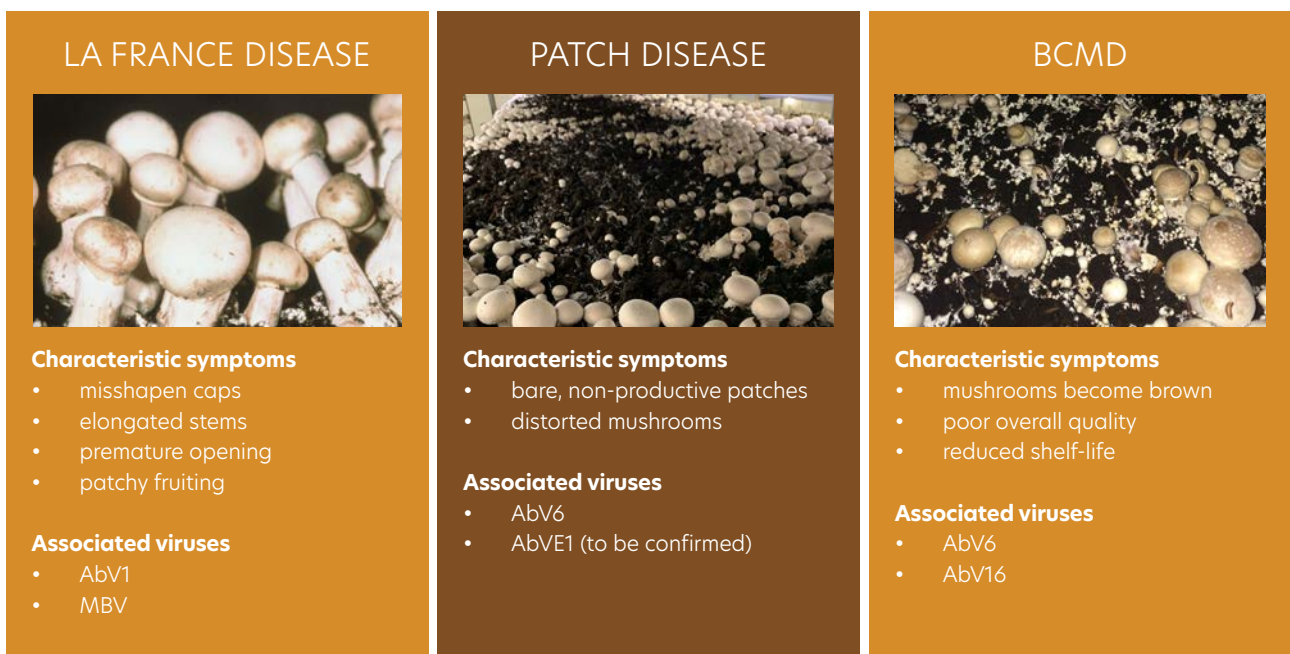


Figure 1 Comparative features of the three known mushroom virus diseases a) La France Disease b) Patch Disease c) Brown Cap Mushroom Disease. Images: a) John Fletcher personal collection; b & c) farm-supplied

**Table 1.** Industry virus survey results

FARM	SAMPLE	VIRUS DETECTED			
		AbV16	AbV6	MBV	AbV1
A	1	—	+	—	—
	2	—	+	+	—
	3	—	+	+	—
B	1	—	—	+	—
	2	—	—	+	—
	3	—	—	+	—
	4	—	—	+	—
C	1	—	—	—	—
D	1	—	—	—	—
	2	—	—	—	—
	3	—	—	—	—
	4	—	—	—	—
E	1	—	—	—	—
	2	—	—	—	—
	3	—	—	—	—
	4	—	—	—	—
F	1	—	—	+	—
	2	—	—	+	—
	3	—	—	+	—

**Legend:** + virus detected; — virus not detected

Neither the AbV1 nor Abv16 (La France and BCMD respectively) viruses were detected in the crops sampled. However, both of the ancillary viruses MBV (La France) and AbV6 (Patch and BCMD) were present in Australian mushroom crops. The good news was that because these viruses were present in isolation, they were not causing disease symptoms in mushrooms.

Although the number of farms participating was small and the sample size therefore limited, it is interesting to note that:

- The six farms that participated in the virus survey represent the four eastern states
- The three farms that tested positive for virus were from three different states
- For both states represented by two farms, one farm had virus detected while the other did not
- Of the three farms that tested positive, all had MBV

- Of the three farms that tested positive, only one detected both AbV6 and MBV

## INTERPRETATION

The small sample size means it is not possible to draw any definite conclusions about prevalence of virus on Australian farms. However, the distribution of the detected viruses over four states indicates a viral problem could be developing in the Australian mushroom industry.

The BCMD virus AbV16 has not been detected so far in Australia. Despite this, BCMD-like symptoms identical to those described in the UK have recently expressed in Australian crops. According to Dr Helen Grogan from Tegasc, this suggests that there could be an unidentified virus particle, unique to Australian mushroom crops, which is mimicking the role of AbV16 in BCMD.

The situation with Patch disease remains unclear. The absence of La France virus AbV1 in survey samples, as well as samples from a farm experiencing a virus outbreak, indicates that Patch disease is responsible for the symptoms expressed. Standard virus testing by CHS did not include the suspected AbVE1 virus, so the status of this particle is unknown. AbVE1 will be included in future screens by CHS.

Interestingly, there was a similar case in the US during the project. One of our colleagues from Pennsylvania contacted the project team asking if we had any experience of mushroom crops expressing BCMD-like symptoms where the AbV16 virus particle was not detected. Whether the unidentified virus particle responsible for BCMD-like symptomatology is unique to Australia, or the same as that occurring in the US, is at this stage unknown.

## THE WAY FORWARD...

To determine the virus status of the Australian mushroom industry, AMGA and Hort Innovation have developed a new investment opportunity for a PhD student to study and characterise the entire viral genome found in Australian *Agaricus* crops. This study has the potential to identify the viruses responsible for both the patch disease-like and BCMD-like symptoms expressed in Australian crops. At the time of writing, the RFP for this investment has been issued and the procurement process to identify a suitable delivery partner is underway.



## RECOMMENDED READING

Allan J (2020) Mushroom virus – frustrating and costly. *Australian Mushrooms Journal* 4:22-25 [available on AGORA]

Allan J (2021) Australian mushroom industry virus survey to commence in December 2021. *Australian Mushrooms Journal* 4:28-29 [accessible on AGORA]

Dobbs E, Deakin G, Bennett J, Fleming-Archibald C, Jones I, Grogan H, Burton K (2021) Viral interactions and pathogenesis during multiple viral infections in *Agaricus bisporus*. *mBio* 12:e03470-20 [accessible from Google Scholar]

Fletcher JT, Gaze RH (2008) *Mushroom Pest and Disease Control: a color handbook*. Academic Press

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Hollings M (1962) Viruses associated with a die-back disease of cultivated mushroom. *Nature* 196:962-965 [accessible from Google Scholar]

Sinden JW, Hauser E (1950) Report on two new mushroom diseases. *Mushroom Science* 1:96-100 [accessible through the MU21007 Project Team]



### FOR FURTHER INFORMATION CONTACT THE PROJECT TEAM

Judy Allan | [judyallan@bigpond.com](mailto:judyallan@bigpond.com) | (02) 6767 1057

Warwick Gill | [warwick.gill@utas.edu.au](mailto:warwick.gill@utas.edu.au) | 0417 766 588



Figure 2 Virus expressing in a mushroom bed. Image: Farm supplied.