

## The progressive failure of VPM resistance to all three wheat rusts on the Australian continent

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The VPM resistance comprises three rust resistance genes *Yr17*, *Sr38* and *Lr37* that occur on a translocation segment derived from *Triticum ventricosum* and has been widely incorporated into common wheat germplasm in Australia. The Australian continent is divided into three wheat growing regions: the summer-dominant rainfall areas of northern NSW and Queensland (Region 1); the uniform and winter-dominant rainfall areas from NSW, Victoria, South Australia and Tasmania (Region 2); the winter-dominant rainfall area of southwestern Western Australia (Region 3). Region 3 is separated from the remaining wheat growing regions by more than 1000 km of desert.

Virulence for *Yr17*, *Sr38* and *Lr37* has evolved over time and space in the Australian wheat rust flora (Table 1). The deployment of the VPM resistance in the variety Camm in Region 3 provided the selective pressure for virulence evolution to *Yr17*, *Sr38* and *Lr37*, yet virulence only evolved for *Sr38* and *Lr37*. Wheat stripe rust pathotype 134 E16 YrA+ was introduced to Region 3 in 2002 from USA, yet no further step-wise mutations have occurred despite occasional severe epidemics. In contrast, 134 E16 YrA+ spread rapidly in eastern regions where it produced two derivative pathotypes with virulence for *Yr17*; these pathotypes caused commercial yield losses. Virulence for *Yr17* in earlier pathotypes did not impact the wheat industry.

**Table 1.** The distribution and lineages of pathotypes of wheat stem, leaf and stripe rusts with VPM virulence in Australia, including their current distribution across the three wheat growing regions.

	Pathotype	Year detected	Present in Australian wheat regions <sup>1</sup>			Derived pathotypes	Present in Australian wheat regions <sup>1</sup>		
			1	2	3				
Wheat stem rust ( <i>Puccinia graminis</i> f. sp. <i>tritici</i> )	34-1,2,7 +Sr38	2001	1	2	3	34-1,2,7 +Sr38 +Sr21 34-1,2,7 +Sr38 +Yalta Low 34-1,2,7,10 +Sr38		2	3
Wheat leaf rust ( <i>Puccinia triticina</i> )	104-1,2,3,(6),(7),11 +Lr37	2002	1	2	3				
Wheat stripe rust ( <i>Puccinia striiformis</i> f. sp. <i>tritici</i> )	104 E137 +Yr17	1999	1	2					
	104 E137 +YrA +Yr17	2000		2					
	134 E16 +YrA +Yr17	2006	1	2		134 E16 +YrA +Yr17 +Yr27	1	2	

<sup>1</sup> Numbers in bold indicate the wheat region where the pathotype was first detected.