

A Proposal for a Uniform Genetic Nomenclature for Avirulence Genes in Phytopathogenic *Pseudomonads*

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The cloning of cultivar-specific avirulence genes from phytopathogenic bacteria of the genus *Pseudomonas* (Staskawicz *et al.* 1984, 1987; Kobayashi *et al.* 1989, 1990) has opened up a new era of knowledge concerning the role of bacterial genes in pathogenicity. As with any rapidly developing field there is the possibility that confusion may arise as a result of conflicting or alternative systems of nomenclature. It would thus appear timely to attempt to devise a uniform system of nomenclature for the designation of all avirulence genes and to canvas the widest possible adoption of the resulting system.

Such a system should, as far as practicable, be in keeping with the existing bacterial genetics nomenclature (Demerec *et al.* 1966), while at the same time providing a readily understandable designation that reflects the 'interactive' nature of such genes. To this end it is proposed that avirulence genes recognized because of matching genes for resistance in either host or non-host plants be designated *avr*.

Further designation should encompass three objectives: 1) the source of the *avr* gene; 2) the nature of the host gene that defines the *avr* gene and (3) nonambiguity. The system of Demerec *et al.* (1966) would identify separate genes by a capital letter (thus *avrA*, *avrB*, etc.). We propose to retain this system, but to indicate source we would propose that the gene letter be prefixed by a three-letter designation relating to the source of the gene. Ideally, this would comprise the first letter of the generic name, followed by the first two letters of the species or pathovar name, except where duplication or ambiguous letters such as 'l' (which could be confused with the number 1) arise. The suggested designations for pseudomonads included in the list of approved pathovar names of Dye *et al.* (1980) are given in Tables 1 and 2. Thus the avirulence gene, identified by Vivian *et al.* (1989) in *P. syringae* pv. *pisi*, would be designated *avrPpiA*. To accommodate the need to avoid ambiguity and to recognize potential alleles from different isolates of a pathovar it would be appropriate to include an allele number, thus *avrPpiA1*.

The above would provide a simple nomenclature in keeping with that of Demerec *et al.* (1966), but would not address the issue of the matching resistance gene that defined the *avr* gene. We therefore propose that an additional designation for the host resistance gene be added

after a period (full stop); thus *avrPpiA1.R2*, since the avirulence gene is recognized by incompatibility toward pea (*Pisum sativum*) cultivars carrying the *R2* gene for resistance to pea blight (Taylor *et al.* 1989). The designation beyond the period would be optional, allowing for those situations where the resistance gene was yet to be designated and for non-host genes where the host gene may need a fuller designation.

Table 1. Proposed prefix designations for avirulence genes among phytopathogen species of *Pseudomonas*

Prefix	Species	Prefix	Species
Pag	<i>P. agarici</i>	Pfu	<i>P. fuscovaginae</i>
Pam	<i>P. amygdali</i>	Pgm	<i>P. glumae</i>
Pan	<i>P. andropogonis</i>	Phi	<i>P. hibiscicola</i>
Pas	<i>P. asplenii</i>	Pmi	<i>P. meliae</i>
Pav	<i>P. avenae</i>	Prn	<i>P. rubrilineans</i>
Pca	<i>P. caricapapayae</i>	Prs	<i>P. rubricubalicans</i>
Pce	<i>P. cepacia</i>	Pso	<i>P. solanacearum</i>
Pcy	<i>P. caryophylli</i>	Pts	<i>P. tolaasii</i>
Pci	<i>P. cichorii</i>	Pvf	<i>P. viridiflava</i>
Pco	<i>P. corrugata</i>		

Table 2. Proposed prefix designations for pathovars of *Pseudomonas*

Prefix	Species and pathovar	Prefix	Species and pathovar
Pgg	<i>P. gladioli</i> pv. <i>gladioli</i>	Plp	<i>P. s. pv. lapsa</i>
Pga	<i>P. g. pv. alliiicola</i>	Pma	<i>P. s. pv. maculicola</i>
Pmm	<i>P. marginalis</i> pv. <i>marginalis</i>	Pme	<i>P. s. pv. mellea</i>
Pmf	<i>P. m. pv. alfalfae</i>	Pmo	<i>P. s. pv. mori</i>
Pmt	<i>P. m. pv. pastinaceae</i>	Pmp	<i>P. s. pv. morsprunorum</i>
Psy	<i>P. syringae</i> pv. <i>syringae</i>	Ppa	<i>P. s. pv. panici</i>
Pac	<i>P. s. pv. aceris</i>	Ppp	<i>P. s. pv. papulans</i>
Pat	<i>P. s. pv. antirrhini</i>	Pps	<i>P. s. pv. passiflorae</i>
Pap	<i>P. s. pv. apii</i>	Ppe	<i>P. s. pv. persicae</i>
Ptt	<i>P. s. pv. aptata</i>	Pph	<i>P. s. pv. phaseolicola</i>
Paf	<i>P. s. pv. atrofaciens</i>	Ppd	<i>P. s. pv. philadelphi</i>
Par	<i>P. s. pv. atropurpurea</i>	Ppi	<i>P. s. pv. pisi</i>
Pbb	<i>P. s. pv. berberidis</i>	Ppo	<i>P. s. pv. porri</i>
Pcb	<i>P. s. pv. cannabina</i>	Ppr	<i>P. s. pv. primulae</i>
Pcc	<i>P. s. pv. ciccaronei</i>	Pri	<i>P. s. pv. ribicola</i>
Pcn	<i>P. s. pv. coronafaciens</i>	Psv	<i>P. s. pv. savastanoi</i>
Pdp	<i>P. s. pv. delphinii</i>	Pse	<i>P. s. pv. sesami</i>
Pdy	<i>P. s. pv. dysoxylis</i>	Psf	<i>P. s. pv. striafaciens</i>
Per	<i>P. s. pv. eriobotryae</i>	Pta	<i>P. s. pv. tabaci</i>
Pgc	<i>P. s. pv. garcae</i>	Ptg	<i>P. s. pv. tagetis</i>
Pgy	<i>P. s. pv. glycinea</i>	Pth	<i>P. s. pv. theae</i>
Phe	<i>P. s. pv. helianthi</i>	Pto	<i>P. s. pv. tomato</i>
Pja	<i>P. s. pv. japonica</i>	Pum	<i>P. s. pv. ulmi</i>
Pla	<i>P. s. pv. lachrymans</i>	Pvi	<i>P. s. pv. viburni</i>

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Table 3. Proposed nomenclature for avirulence genes cloned from phytopathogenic pseudomonads

Species and current designation	Proposed designation ^a	Reference
<i>P. s. pv. glycinea</i>		
<i>avrA</i>	<i>avrPgyAl.Rpg2</i>	Staskawicz <i>et al.</i> (1984)
<i>avrB</i>	<i>avrPgyBl.Rpg1</i>	Tamaki <i>et al.</i> (1988)
<i>avrC</i>	<i>avrPgyCl.Rpg3</i>	Tamaki <i>et al.</i> (1988)
<i>P. s. pv. maculicola</i>		
<i>avrRpm1</i>	<i>avrPmaAl.RPM1</i>	Debener <i>et al.</i> (1991)
<i>P. s. pv. phaseolicola</i>		
<i>avrA</i>	<i>avrPphAl</i>	Shintaku <i>et al.</i> (1989)
<i>avrPph3</i>	<i>avrPphBl.R3</i>	Jenner <i>et al.</i> (1991)
<i>P. s. pv. pisi</i>		
<i>avrAspil</i>	<i>avrPpiAl.R2</i>	Vivian <i>et al.</i> (1989)
<i>avrPpi3</i>	<i>avrPpiBl.R3</i>	Bavage <i>et al.</i> (1991)
<i>P. s. pv. tomato</i>		
<i>avrD</i>	<i>avrPtoAl</i>	Kobayashi <i>et al.</i> (1990)
<i>avrPto</i>	<i>avrPtoCl</i>	Bent <i>et al.</i> (1991)
<i>avrRpt2</i>	<i>avrPtoBl</i>	Whalen <i>et al.</i> (1991)

^a Allele numbers would normally be assigned by original investigators.

Table 3 lists the proposed nomenclature for avirulence genes cloned from phytopathogenic *Pseudomonas* species. Where the existence of the matching *R* genes has been confirmed by formal genetics, as in soybean (Keen and Buzzell 1991), designation of the resistance gene has been included. It would be the responsibility of the originating laboratories to provide allele designations. Where more than one laboratory is assigning allele numbers in a particular pathovar or species, it will be necessary for them to agree a series of nonoverlapping numbers. The system could be similarly extended to other genera such as *Xanthomonas*.

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