2008-2009 CEREAL RUST SURVEY ANNUAL REPORT

I. SUMMARY

A total of 1,089 samples were received during the 2008-09 survey, which ended on March 31 2009. The majority of samples (840) were from crops affected with stripe rust, although even this was confined mostly to NSW and Qld, which experienced early disease onset and average to above average growing conditions that also favoured stripe rust development. New pathotypes of the pathogens causing wheat stripe rust, barley leaf rust and oat crown rust were detected.

Wheat stem rust: Stem rust incidence was very low throughout Australia, and very few of the 59 samples received came from commercial wheat crops. Seven pathotypes were identified, with pts 34-1,2,7 +Sr38, 98-1,2,3,5,6,7 and 343-1,2,3,5,6 being the most commonly isolated.

Wheat leaf rust: Leaf rust incidence was also very low, with most samples originating from experimental plots. Eight pathotypes were identified from the 27 samples received, the most common being members of the standard race 104 lineage.

Wheat stripe rust: A severe and extended epidemic was confined largely to NSW and Qld, with fungicide control measures estimated at *ca*. $40-50 million. The dominant 'Jackie' pathotype was detected early on long season cereals. The 'WA Yr17' pathotype was detected in 13% of isolates, a similar rate of recovery to 2007. This pathotype caused concern on varieties carrying *Yr17*. A new pathotype with virulence for *Yr27* was detected late in the season (viz. the 'Jackie Yr27' pathotype), which is expected to cause increased stripe rust damage on varieties carrying *Yr27*.

Oat crown rust: Although the incidence of crown rust was generally low throughout Australia, it was more common in north eastern Australia than it had been in recent years. As in previous years, pts 0001-0 and 0000-2 predominated in SE Australia and in WA, and pathotype diversity was higher in the NE. Two new pathotypes with virulence for cv Volta were detected.

Oat stem rust: A higher sample number was recorded in 2008, predominately from regions in NSW and Qld that experienced favourable spring-summer rainfall. A surprisingly high frequency of virulence for *Pga* was determined among the isolates recovered from eastern Australia.

Barley leaf rust: Incidence of barley leaf rust was low in all regions except the NE, where it reached epidemic levels and some crops were sprayed. Six pathotypes were detected, of which pt 5453 P+ predominated in the NE. A new pathotype with virulence for Rph3 (viz. 5753 P+) was detected from NNSW in early 2009.

Barley stem rust: There were no reports of stem rust in crops of barley in 2008. Two samples from which viable isolates were established, both from NE Australia, comprised the scabrum rust.
***Barley grass stripe rust*:** An increased number of samples from barley grass in 2008 yielded both wheat stripe rust, and the barley grass stripe rust (BGYR) form of the pathogen. The majority of BGYR isolates were recovered from NSW, while Western Australia remains free of this form.

Triticale and rye rusts: There were no reports of stem rust or leaf rust in commercial triticale and rye crops during the 2008 cropping cycle. There were, however, many reports of stripe rust in triticale, associated with the new triticale attacking pathotype.

II. DETAILED REPORT

SEASONAL CONDITIONS

Wheat production in Australia in 2008-09 was estimated at 21.4 million tonnes. This represented a substantial increase over the previous five year average of 19.5, but was still below the expectations set in the middle of the growing season in many areas. Barley, oats and triticale yields were at or near the five year average, with aggregated production estimated at 8.5 million tonnes.

In general, autumn-early winter rainfall in 2008 across all districts was adequate for sowing operations. With the exception of Queensland, the majority of regions experienced average to below average rainfall during winter. Adequate crop establishment occurred through winter and early spring across most regions where temperature and moisture conditions prevailed. However, only northern NSW, southern Queensland and Western Australia received sufficient spring rainfall to complete grain fill and so realise expected yields. Below average spring rain and minimal moisture storage in soil profiles across much of southern NSW, Victoria and South Australia resulted in reduced yield for these areas.

Sources:
ABARE 'Australian Crop Reports' www.abareconomics.com
Australian Bureau of Meteorology http://www.bom.gov.au/climate/austmaps/

WHEAT RUST PATHOGENS

Wheat Stem Rust (caused by *Puccinia graminis* f. sp. *tritici*)
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Epidemiology and Pathotype Distribution

The incidence of stem rust of wheat was very low in 2008-09, and few if any of the 59 samples received came from commercial wheat crops. About half of these samples came from inoculated experimental plots at Gatton Qld (8) and Carnarvon WA (20). Viable stem rust isolates were established from 47 of the 59 samples, and from these, seven pathotypes were identified (Table 1). No samples of stem rusted wheat were received from SA, Victoria, Tasmania or southern NSW.

Six pathotypes were identified from samples forwarded from WA, five of which were present in experimental plots at Carnarvon (34-1,2,7 +Sr38; 34-1,2,7 +Sr38 [Yalta low]; 98-1,2,3,5,6,7; 222-1,2,3,5,6,7; 343-1,2,3,5,6). Pathotypes identified from non-inoculated plots/ crops were 34-1,2,7 +Sr38 and 98-1,2,3,5,6,7. Eight of the 12 samples received from Queensland came from inoculated plots at Gatton, from which three pathotypes were identified (34-1,2,7 +Sr38; 98-1,2,3,5,6; 343-1,2,3,5,6). The remaining samples from Queensland and four samples from northern NSW comprised pts 34-1,2,7 +Sr38, 222-1,2,3,5,6,7, and the Satu triticale pathotype 34-2,12,13. Four isolates of the latter pathotype were identified, from both northern NSW and Qld. This pathotype has been isolated only rarely since 1990; two isolates were recovered from Toowoomba in 1991, a single isolate from Narrabri in 1995, a single isolate from Wellcamp in 1997, and a single isolate from Kingsthorpe in 2006.

Pathotypes Isolated

The seven pathotypes isolated during 2008-09 belong to two clonal lineages:

1. The "race 21" lineage. Established following the introduction of pt 21-0, which was first detected in 1954-

• 34-1,2,7 +Sr38	The "VPM" pathotype. Derived from pathotype 34-1,2,7 via acquisition of virulence for *Sr38*.This pathotype was first detected in WA in 2001, and presumably spread to eastern Australia, where it was first detected at Arno Bay (SA) in Nov 2003. It has now been detected in all Australian states.
• 34-1,2,7 +Sr38 +Norin 40	Derived from 34-1,2,7 +Sr38 via acquisition for an uncatalogued resistance gene in Norin 40. This resistance gene is not present in Australian wheat cultivars.
• 34-2,12,13	The Satu triticale pathotype, arose from the Coorong triticale pathotype (34-2,12) via acquisition of virulence for *SrSatu*. First detected in 1984.

2. The "race 326" lineage. Established following the introduction of pt 326-1,2,3,5,6, which was first detected in 1969-

• 343-1,2,3,5,6	Derived from pt 326-1,2,3,5,6 via acquisition of virulence for *Sr5*. The "Oxley" pathotype.
• 98-1,2,3,5,6	Derived from pt 343-1,2,3,5,6 via acquisition of virulence *Sr9g*. The "Paterson" pathotype.
• 98-1,2,3,5,6,7	Derived from pt 98-1,2,3,5,6 via acquisition of virulence for *Sr15*. The "Wyalkatchem" pathotype.

3. The "race 194" lineage. Established following the introduction of pt 194-1,2,3,5,6, which was first detected in 1969-

• 222-1,2,3,5,6,7	Derived from pt 194-1,2,3,5,6 by via acquisition of virulence for *Sr5* (to give pt 222-1,2,3,5,6) and *Sr15*.

Notes on Cultivars Carrying Genes for Stem Rust Resistance

The stem rust responses of wheat cultivars are not expected to change from those of 2008.

Sr24	Annuello, Babbler, Carinya, Catalina, Clearfield JNZ, Cunningham, Dakota, Datatine, EGA Bullaring, EGA Burke, EGA Eagle Rock, EGA Jaegar, EGA Jitarning, EGA Wentworth, EGA Wills, GBA Combat, GBA Sapphire, Giles, Gladius, Guardian, Janz, Krichauff, Lang, Mira, Mitre, Naparoo, Pardalote, Petrie, QAL2000, QALBis, Sunco, Sunsoft 98, Yenda and Worrakatta
Sr26	Blade, Chough, Currawong, Darter, Petrel, Snipe, Sunlin, and Wylah
Sr30	1. (close monitoring required; significant rust may develop even with *Sr30*-avirulent isolates): Ajana, Arrino (heterogeneous), Kalgarin, Yitpi 2. Batavia, Brookton, Calingiri, Chara, Cunderdin, EGA Bonnie Rock, EGA Hume, EGA Wedgetail, Frame, H45, Kalannie, Katunga, Lark, Lorikeet, Osprey, Rosella, Silverstar, Sunfield, Sunmist.
Sr31	GBA Hunter, Grebe, Tennant, Warbler and Zebu
Sr33	Lorikeet
Sr45	Thornbill

The gene *Sr2* confers adequate adult plant resistance and is present in the cultivars Baxter, Bowerbird, Braewood, Brennan, Carnamah, Crusader, Derrimut, Diamondbird, Drysdale, EGA Bounty, EGA Bullaring, EGA Burke, EGA Eaglehawk, EGA Kidman, EGA Wentworth, EGA Wylie, Ellison, Eradu, Hartog, Kennedy, Kukri, Leichardt, Livingston, Machete, Mackellar, Merinda, Peake, Rees, Sunbrook, Sunstate, Sunzell and Ventura. Cultivars with *Sr13* (AGT Scythe, Axe (?), Clearfield STL, Gascoine (?), Machete, Stiletto, Sunmist and Wialki) are moderately susceptible to resistant, depending upon the presence of additional resistance genes. Given that virulence for *Sr36* has not been detected since 1997, and since 1986 has only been detected on seven occasions, cultivars carrying this gene (Baxter (heterogeneous) and EGA Wylie) can be considered resistant but with some caution. Cultivars carrying the combination of *Sr36* and *Sr38* (Braewood, Ellison, Sunbri and Sunvale) and *Sr24* (Lang, Sunco, Sunvale and Young) are resistant to all known stem rust pathotypes.

Wheat Leaf Rust (caused by *Puccinia triticina*; formerly *Puccinia recondita* f. sp. *tritici*)

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Epidemiology and Pathotype Distribution

Levels of leaf rust in wheat were low throughout Australia in 2008-09, with only 27 samples being forwarded for processing (Table 2). This continues the trend of low disease incidence observed during the previous two survey periods 2006-07 (28 samples) and 2007-08 (18 samples). No samples of leaf rusted wheat were received from SA or Tasmania.

Of the three samples forwarded from WA, two came from inoculated plots at Carnarvon and one from Northampton. Three pathotypes were identified, all of which have been present in WA in recent years (viz. 104-1,2,3,(6),(7),11; 104-1,2,3,(6),(7),11 +Gaza high; 104-1,2,3,(6),(7),11 +Lr37).

Seven pathotypes were detected in eastern Australia, belonging to four different clonal lineages (Table 2 and see below). Two isolates of the Mackellar pathotype, 10-1,3,9,10,11,12 were isolated from southern NSW, from experimental plots at Yanco in November. These samples also comprised pt 76-3,5,9,10 +Lr37, which was also isolated from northern NSW from the Plant Breeding Institute at Narrabri. A presumed mutational derivative of this pathotype with added virulence for *Lr17b* (pt 76-3,5,9,10,12 +Lr37) was also isolated from Narrabri from a sample collected in mid October. Single isolates of the “Paterson” pathotype, 76-1,3,5,9,10,12, were identified in samples forwarded from Narrabri and Gatton.

Four pathotypes within the 104- lineage were isolated during 2008-09, including the Lr37-virulent pathotype (104-1,2,3,(6),(7),11 +Lr37) and the Lr24-virulent pathotype (104-1,2,3,(6),(7),11,13). The latter was isolated from Queensland (Gatton and Kingaroy), southern NSW (Yanco) and Victoria (Hamilton and Mayrang).

Pathotypes Isolated

The seven pathotypes of *P. triticina* isolated during 2008-09 are believed to belong to one of four clonal lineages:

<u>1. The “104-2,3,(6),(7),11” lineage.</u> Pt 104-2,3,(6),(7),11 was first detected in a sample collected from Mt Derimut in Victoria in July 1984. We have since detected many single step mutational derivatives, and with few exceptions, one or more of these pathotypes have been the most frequently isolated pathotype in all regions of Australia surveyed in the years since 1989. Four pathotypes were isolated in 2008-09:

• Pt 104-1,2,3,(6),(7),11	Derived from pt 104-2,3,(6),(7),11 via acquisition of virulence for *Lr20*. First detected in NSW in 1989 and subsequently spread to all Australian wheat growing regions.
• Pt 104-1,2,3,(6),(7),11 +GH	Derived from pt 104-1,2,3,(6),(7),11 via acquisition of virulence for an uncharaterised seedling resistance gene present in the *Lr23* tester Gaza. This uncharaterised resistance gene is effective against other

	pathotypes within the "104-2,3,(6),(7),11" lineage, and is ineffective to all other Australian pathotypes of *P. triticina* virulent for *Lr23*.
• Pt 104-1,2,3,(6),(7),11,13	The "Lr24" pathotype. Derived from pt 104-1,2,3,(6),(7),11 via acquisition of virulence for *Lr24*. This pathotype was first detected in SA in October 2000, and has since been isolated from all eastern states. It is not known to occur in WA.
• Pt 104-1,2,3,(6),(7),11 +Lr37	The "VPM" pathotype. Derived from pt 104-1,2,3,(6),(7),11 via acquisition of virulence for *Lr37*. This pathotype was first detected in WA early in 2002 from self sown Camm near Albany. It was subsequently detected in the south eastern corner of SA in December 2002 and is now well established in all wheat growing regions.

<u>2. The "Mackellar" lineage.</u> Pt 10-1,3,9,10,11,12 was first isolated from Victoria at Bairnsdale in October 2004, and is now known to be more widespread in Victoria, NSW and Tasmania. This pathotype has a number of unusual attributes and is regarded as an exotic introduction.

<u>3. The 76-3,5,9,10 +Lr37 lineage.</u> Regarded as an exotic introduction, first isolated from Inverleigh (Vic) in late July 2006, and now present throughout Victoria, southern and northern NSW and South Australia.

<u>4. The "Paterson" lineage.</u> Pt 76-1,3,5,10,12 was first detected from NSW in 1996, and is believed to have been introduced to Australia from New Zealand, where it had been present since 1989. This pathotype has now been isolated from Victoria, SA and Tasmania. It has remained at a low incidence but was associated with an epidemic of leaf rust in the western district of Victoria in 1999. A single mutational derivative with virulence for *Lr1* (pt 104-1,3,5,10,12) was isolated from Wanilla (SA) in 2002.

Notes on Cultivars Carrying Genes for Leaf Rust Resistance

Cultivars with *Lr17a* (Baxter, heterogeneous; Perenjori; Teesdale) are considered resistant to all prevailing pathotypes, however, there is evidence from seedling tests that the new pt 76-3,5,10 +Lr37 may be fully virulent for this gene and further testing is needed to understand this more fully.

Cultivars with *Lr13* in combination with *Lr1* (Batavia, Bowerbird, Cunderdin, Diamondbird, Glover, Hartog, Kukri, Leichardt, Sunbrook, Sunfield and Tailorbird) or *Lr2a* (Sunmist) could be vulnerable to the new "Mackellar" pathotype.

Cultivars with *Lr13* in combination with *Lr23* (EGA Hume, EGA Kidman, Kennedy, Strzelecki) or *Lr24* (GBA Combat, Giles, Gladius, Merinda, Naparoo, Petrie and Sunsoft 98) are resistant to all pathotypes isolated in 2008-09. Cultivars carrying *Lr13* and *Lr37* (Braewood, Derrimut, Ellison, H46, Rudd, Sunstate and Young) may be vulnerable to the new pt 76-3,5,10 +Lr37. The combination of *Lr13* and *Lr17b*, found in several winter wheats (Gordon, Mackellar, Paterson) is ineffective in protecting against pt 10-1,3,9,10,11,12. Declic, which carries *Lr14a* in addition to *Lr13* and *Lr17b*, is seedling susceptible to pt 10-1,3,9,10,11,12.

Cultivars with *Lr26* (GBA Hunter, Grebe, Tennant and Warbler) are at least seedling susceptible to pts 104-1,2,3,(6),(7),9,11, 10-1,3,9,10,11,12 and 76-3,5,9,10 +Lr37. Field data from 2005 suggest that Tennant is rated "S" (susceptible) to the "Mackellar' pathotype. Mawson is seedling susceptible to pt 76-3,5,9,10 +Lr37 but carries an unidentified seedling resistance gene that is effective against pt 10-1,3,9,10,11,12.

Carinya, EGA Jaegar QAL2000 and QAL Bis (*Lr24* + *Lr37*) are resistant to all pathotypes isolated from Australasia during the 2008-09 survey period.

Cultivars with *Lr21* (Thornbill), *Lr28* (Sunland) and the complementary seedling resistance genes *Lr27+Lr31* (Carnamah and Karlgarin) are resistant to all pathotypes isolated in 2008-09. Genetic studies at PBIC have indicated that Carnamah and Kalgarin should also carry the adult plant resistance gene *Lr12*, which is completely linked to *Lr31*, and in fact may be the same gene.

It is apparent that many cultivars protected previously by *Lr24*, and at least some cultivars protected previously by *Lr37* have some adult plant resistance to pathotypes virulent for these genes. This includes the resistance gene *Lr34*.

The combination of *Lr1*, *Lr13* and *Lr37* (Crusader, EGA Eaglehawk, Livingston, Sunlin, Sunstate and Sunzell) remains effective.

<u>Wheat Stripe Rust</u> (caused by *Puccinia striiformis* f. sp. *tritici*)

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Disease development

The first sample was received from Tobruk triticale (Young, southern NSW) on 16th May 2008. A site comprising well infected stubble sampled in the Lake George area suggested that infection may have initiated as early as mid April. This was a very early occurrence based on previous seasons. Mild temperatures and adequate soil moisture in early winter favored crop growth and stripe rust development. Although cold temperatures in late winter slowed infection cycles, the quantities of inoculum in commercial fields was already sufficient to cause serious concern for warmer spring conditions.

The 2008 epidemic, which recorded the highest sample number processed through the PBI Rust Laboratory since work began with stripe rust in 1979, was nevertheless confined largely to central and northern NSW, and southern Queensland. These regions experienced average and above average spring rainfall, resulting in peak epidemic intensity throughout much of September and early October. In contrast, an above average warm to hot and dry period in mid September checked stripe rust development in most of south eastern Australia. Daily maximum temperatures in this period ranged from 24 to 30^{0}C, although overnight minimum temperatures were generally 10^{0}C or lower. In these conditions, the stripe rust pathogen is capable of surviving in infected tissue and then re-emerging when cooler conditions return.

The low sample numbers for Western Australia in 2008 suggests that there was little if any crop damage due to stripe rust. The reasons for this remain unclear, although the hot dry summer of 2007-08 no doubt contributed to minimal pathogen survival in the green bridge.

Pathotype Distribution

The distribution of pathotypes recorded in 2008 is presented in Table 3. The original 'WA' pathotype, first introduced to Western Australia in 2002 and in the eastern states in 2003, comprised 20 percent of isolates. This pathotype remains the only stripe rust pathotype recorded in Western Australia.

The first mutational derivative, recorded in 2006, was the 'WA Yr17' pathotype. This pathotype was at low frequency in the first year, but rose to 13 percent in 2007. The relative frequency remained the same in 2008, although the 'WA Yr17' pathotype was recorded in Queensland for the first time. This pathotype is capable of causing damage on varieties carrying *Yr17*, and thus it was important to maintain a monitor on the progressive distribution of the 'WA Yr17' pathotype.

The 'Jackie' pathotype, which was first recorded in 2007, is particularly adapted to triticales carrying the matching resistance gene, tentatively referred to as *YrJ*. However wheat varieties with low levels of resistance are also vulnerable to this pathotype. For reasons that remain unclear, the 'Jackie' pathotype was very common in its first year of detection and in 2008 clearly dominated the pathogen population with a recovery rate of 60 percent. The dominance of this pathotype, particularly in the early phase of the epidemic, meant that varieties carrying *Yr17* performed very well and did not need fungicide support. However, the 'WA Yr17' pathotype re-emerged in spring and vulnerable varieties were sprayed as required.

A new pathotype was detected late in 2008. This pathotype is a single gene mutation derivative from the dominant 'Jackie' pathotype, but with the ability to cause disease on the resistance gene *Yr27*. The newly named 'Jackie Yr27' pathotype was recovered from northern Victoria, central and northern NSW, but at very low levels (Table 3).

The comparative features of the pathotypes are illustrated below. Note that where an S response is indicated, it is assumed that there are no additional supporting resistances present.

Pathotype	Year of First Occurrence	Disease Reaction on Major Resistance Gene *Yr17*	*YrJ*	*Yr27*
WA pathotype 134 E16 A+	2002	R	R	R
'WA Yr17' pathotype 134 E16 A+ Yr17+	2006	S	R	R
'Jackie' pathotype 134 E16 A+ J+	2007	R	S	R
'WA Yr27' pathotype 134 E16 A+ J+ Yr27+	2008	R	S	S

Stripe rust on barley grass

An unusually high number of samples of stripe rust on barley grass were received in 2008. Approximately half of the samples were determined as BGYR, and this was the expected result (see section below on Barley Rust Pathogens).
However the remaining barley grass samples yielded the 'Jackie' pathotype. Previous work has demonstrated that wheat stripe rust pathotypes can adapt to resistance in weedy barley grass communities, and this adaptation hypothesis will now be tested for isolates of the 'Jackie' pathotype recovered from barley grass.

Notes on current resistances

Yr17
There are a large number of commercial varieties carrying this gene, and these will be expected to be resistant to three of the four pathotypes detected in 2008. The pathotype causing concern for these wheats is the 'WA Yr17' pathotype. However, the extent of concern will vary across varieties according to the levels of supporting resistance that continue to provide some level of protection. Varieties that carry Yr17 and are considered highly vulnerable to the 'WA Yr17' pathotype are Fang, H46, Pugsley, Qal 2000, QAL Bis, Trident. The expected response of Yr17 varieties to *Yr17* avirulent and virulent pathotypes is detailed in Cereal Rust Report Volume 7 Number 3 (March 2009).

Yr27
A group of varieties carrying *Yr27* are now potentially vulnerable to the 'Jackie Yr27" pathotype. These varieties include GBA Hunter, GBA Ruby, Mira, Merinda, Waagan, Zebu. The resonse of these varities to this new pathotyoe will be monitored in 2009 field experiments.

Note that variety Livingston, carrying both *Yr17* and *Yr27* in combination, will remain resistant to all current pathotypes.

Yr33
This gene is present in varieties EGA Gregory and Strzelecki, and is expected to remain resistant to current pathotypes.

The response of current Australian varieties to stripe rust pathotypes is available in Cereal Rust Report Volume 7 Number 3 (March 2009). The known resistance genotype of Australian wheats is reported in Cereal Rust Report Volume 7 Number 2 (March 2009).

OAT RUST PATHOGENS

Oat Stem Rust (caused by *Puccinia graminis* f. sp. *avenae*)
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A total of 34 samples were received, which represented a large increase over the previous season. However, overall sample numbers remain at historic lows. The majority of samples originated from northern NSW and Queensland (Table 4), which no doubt reflected the above average spring-summer rainfall conditions in this region.

The major pathotype group comprised Race 94, with variants within this group showing combinations of virulence for *Pg13, PgSaia* and *Pga*. Approximately 60 percent of isolates were virulent for *Pga* which was a surprisingly high proportion for several reasons. Firstly, this virulence was not recorded in the previous season, although this may have been a consequence of low sample number in 2007. Secondly, virulence for *Pga* had previously reached a peak of just 20 percent in 1999 and progressively decreased to approximately 10 percent in following years. With this background, it is hard to understand why *Pga* virulence has markedly increased and from a seemingly very low base.

The ineffectiveness of *Pga* indicates that varieties carrying this gene (Barcoo, Cleanleaf, Condamine, Culgoa II, Glider, Nobby, Quoll) will be potentially vulnerable.

Oat Crown Rust (caused by *Puccinia coronata* f. sp. *avenae*)
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Epidemiology and Pathotype Distribution

While the overall incidence of crown rust on oats was low in 2008-09, the disease was more common in northern NSW and Queensland than in the past few years, and most (39) of the 56 samples received were collected in this region (Table 5). Of the total number of samples received, 30 came from cultivated oats and 26 from wild oats. Five samples failed to yield viable isolates, and 25 pathotypes were identified from the remaining 51 samples (Table 5).

While evolutionary relationships between the pathotypes of *Pca* identified since 1998 are not fully understood, there is good evidence for at least 5 clonal lineages within the pathogen populations:

1. Pathotypes virulent for differentials carrying *Pc55*, *Pc71* and either or both *Pc38* and *Pc39* (triplet codes 0003, 0007, 0107, 0207, 0307 and others).
2. Pathotypes virulent for differentials carrying *Pc58*, *Pc59* and *Pc61* (triplet codes 0011 and 0071).
3. Pathotypes virulent for differentials *Pc39* and *Pc61* (triplet code 4473).
4. Pathotypes avirulent for all differentials carrying these genes:
    a. triplet code 0000
    b. triplet code 0001

Groups 1 and 2 comprise closely related pathotypes that appear to be clonal lineages, each comprising step-wise mutational derivatives from a common ancestor. Group 1 comprises many pathotypes and is the most diverse clonal lineage. Pathotypes in Groups 1 and 2 have been isolated commonly from northern NSW and Qld and include those carrying virulence corresponding to the cultivars Culgoa, Cleanleaf, Moola, Graza 68, Warrego, Gwydir, Nugene and in 2008 Volta (Group 1), and Amby and Nobby (Group 2). Pathotypes in Group 3 are also virulent on Amby and Nobby, and one pathotype in this group can attack Bettong and Barcoo. It is believed that this group may have arisen via somatic hybridization between isolates from Groups 1 and 2. Pathotypes within Groups 1, 2 and 3 have dominated in northern NSW and Queensland for much of the past 10 years, with Group 1 being the largest lineage with the greatest pathotypic diversity. Pathotypes within lineages 4a and 4b, while also found in northern NSW and Queensland, have dominated in Victoria, SA and WA over the past 10 years.

Pathotypic diversity was high in 2008-09, with 25 pathotypes being identified from the 56 samples received. Of particular importance was the detection of two new pathotypes with virulence for cv Volta. These pathotypes are the first to be detected with virulence matching this cultivar. The virulence spectra of these pathotypes strongly implicate the presence of resistance gene *Pc50* in Volta. Only two other pathotypes of *Pca* have been isolated on Australia carrying virulence for this gene (one in 1976 and another in 1999); nether became common and both are avirulent on Volta indicating that this cultivar carries resistance gene(s) in addition to *Pc50*. Comparative greenhouse tests with the *Pc50* pathotypes suggest that Volta carries *Pc61* in addition to *Pc50*. Pt 0307-3,4,5,6,10 +Warrego +Volta was first isolated from Towoomba in late July, and subsequently from Gatton, Warwick and Kent's Lagoon off both wild oats and cultivated oats in Queensland, and in October from three locations in northern NSW all off wild oats. Pt 0767-3,5,6,10 +Warrego +Volta differs from 0307-3,4,5,6,10 +Warrego +Volta in carrying additional virulence for cv Culgoa, and was identified only once, from a sample collected at Gatton in October. This pathotype is believed to be a mutational derivative of 0007-6,10, via sequential addition of virulence for *Pc52* (cv Cleanleaf; pt 0207-5,6,10), *Pc68* (cvs Moolah and Graza 68; pt 0307-5,6,10), *Pc51* (cv??; pt 0307-4,5,6,10), *Pc61* (cv Warrego and others; pt 0307-4,5,6,10 +Warrego), *Pc50* (0307-3,4,5,6,10 +Warrego +Volta), and then *PcMortlock* (cv Culgoa; 0767-3,5,6,10 +Warrego +Volta). This clearly shows that seedling resistance genes are of little or no value in controlling crown rust in oats. Of further interest in this regard was the detection of virulence for *Pc92* (Table 5), and resistance gene derived from *Avena strigosa* and which has not been deployed in Australia.

Notes on Cultivars Carrying Genes for Crown Rust Resistance

With the exception of cultivar Drover, all current Australian oat cultivars are susceptible to crown rust. It is suspected that Drover carries *Pc91*. Cultivar Taipan, released in 2001, has the Nugene resistance. Some of the cultivars released in Region 1 and regarded at the time of release as resistant to *P. coronata* f. sp. *avenae*, are now susceptible to a range of pathotypes. These cultivars were believed to carry new genes for resistance to *Pca*, but it now seems that the resistance in practically all can be explained on the basis of known resistance genes.

BARLEY RUST PATHOGENS

<u>Barley Stem Rust</u> (caused by *Puccinia graminis*)
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There were no reports of barley crops affected by stem rust in 2008. Twelve samples of stem rusted barley were received, six of which failed to produce a viable rust isolate (Table 6). A single sample from Hermitage Research Station collected in October comprised the "Scabrum" rust. A sample forwarded from Glen Innes in northern NSW, also in October, comprised a mixture of the "Scabrum" rust with added virulence for *Sr21*, and the wheat stem rust pathotype 34-1,2,7 +Sr38. Nine samples of stem rust barley were forwarded from WA from the middle of December to February, all collected in the Esperance district. Five of these failed to yield a viable isolate, and the remaining four all comprised wheat stem rust pathotype 34-1,2,7 +Sr38.

Notes on Cultivars Carrying Genes for Stem Rust Resistance

Stem rust of barley can be caused by either the wheat stem rust pathogen (*Puccinia graminis* f. sp. *tritici*), the cereal rye stem rust pathogen (*Puccinia graminis* f. sp. *secalis*), or the "scabrum" stem rust, which is a somatic (asexual) hybrid between the wheat and rye stem rust pathogens. While little is known about the stem rust resistance of current Australian barley cultivars to stem rust, experience suggests that all cultivars have some susceptibility to this disease. Recent tests by PhD student Ms Lida Derevnina using markers for the resistance gene *Rpg1* have confirmed its presence in cultivars Yerong, Vlamingh and

Pacific Ranger. This gene conferred resistance to stem rust in barley for many years in the USA, before a virulent pathotype was detected in the Great Plains in 1989. It remains unclear whether or not this gene confers resistance under Australian conditions.

Barley Leaf Rust (caused by *Puccinia hordei*)

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Epidemiology and Pathotype Distribution

Incidence of barley leaf rust was low in all regions except northern NSW and Queensland, where it reached epidemic levels and some barley crops were sprayed. A total of 65 samples were received, five of which failed to yield a viable isolate (Table 7).

Serven samples were received from WA, all of which comprised pts 5453P- and/or the derivative pathotype 5453P+ (derived from the former via acquisition of virulence for *Rph19*, the Prior gene or "*RphP*"). Four of these samples were received during the 2008-09 cropping phase (i.e. July-November), and three were collected from volunteer barley at Manjimup and South Sterling during January-February 2009.

Six pathotypes were detected in samples collected from eastern Australia, including the two that were detected in WA (Table 7). The dominant pathotype in all regions in eastern Australia was pt 5453P+. Four of the five pathotypes detected are all believed to belong to a single clonal lineage, derived from pathotype 5453P- via single step mutations for virulence for resistance genes *Rph19* (pt 5453P+), *Rph13* (5453P+ +Rph13), and *Rph3* (5473P+). The latter is the first pathotype to be detected in Australia with virulence for *Rph3*. It was detected from northern NSW in early 2009 and will have implications for cultivars carrying this resistance gene (see below). Three isolates of the unrelated pathotype 5652P+ were identified among samples forwarded from Tasmania. This pathotype was first detected in Tasmania in 1999, and was detected in SA later that year. It was commonly isolated from Victoria and southern NSW in 2000 and 2001, and has been present in these regions in most years since.

Notes on Cultivars Carrying Genes for Leaf Rust Resistance

Many Australian barley cultivars carry seedling genes for resistance to *P. hordei*, however, other than *Rph7* (cv Galaxy), all of these genes are now ineffective against pathotypes that currently prevail and therefore all cultivars must be regarded as having at least some susceptibility to leaf rust. Before 1999–2000, cultivars carrying *Rph12* (Tallon and Lindwall) were resistant to pathotypes occurring in Region 1, however, virulence for *Rph12* now exists in this region and in all others. In fact, all pathotypes isolated during the 2008-09 survey period were virulent for this gene. Cultivars Fitzroy, Yarra and Starmalt carry *Rph3* and are now seedling susceptible to the new pathotype 5473P+. The adult plant responses of these cultivars to this pathotype are however currently unknown, and filed tests will be at PBI using this pathotype and all current Australian barley cultivars during 2009.

Barley Grass Stripe Rust (caused by *Puccinia striiformis*)

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([1]on secondment from NSW Department Industry and Investment)

An increased number of BGYR isolates were recovered in 2008 compared to previous seasons (Table 3). The majority of isolates were derived from barley grass samples in New South Wales, although one isolate was recovered from a barley entry in a trial site in South Australia. BGYR has not been recorded from Western Australia.

TRITICALE AND RYE RUST PATHOGENS

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There were no reports of stem rust or leaf rust in commercial crops of triticale in 2008-09. The four isolates of the Satu triticale pathotype 34-2,12,13 identified during the 2008-09 survey period came from experimental plots of either wheat (3 isolates) or triticale (1 isolate from Falcon triticale). This pathotype has been isolated only rarely since 1990; two isolates were recovered from Toowoomba in 1991, a single isolate from Narrabri in 1995, a single isolate from Wellcamp in 1997, and a single isolate from Kingsthorpe in 2006.

Triticale continues to be affected by stripe rust in commercial plantings in eastern Australia. The 'Jackie' pathotype predominated in the pathogen population (Table 3), and was particularly damaging in early sown crops of Breakwell and Jackie. It is anticipated that these will be rapidly replaced by alternative varieties with improved resistance.

Two samples of stem rust on cereal rye were received in 2008-09, the first from Queensland (typed as cereal rye stem rust), and the second from WA (failed).

Notes on resistance in triticale to stripe rust

The dominance of the 'Jackie' pathotype has resulted in noticeable changes in disease response in commercial triticales. The majority of current Australia triticales carry the *YrJ* resistance, usually in combination with *Yr9*. Current information in regard to expected disease responses in the field for Australian triticales to stripe rust pathotypes was circulated in Cereal Rust Report Volume 7 Number 1 (February 2009) and resistance genotype information is available in Cereal Rust Report Volume 7 Number 2 (March 2009). Both reports are available from the PBI website.

MISCELLANEOUS RUST PATHOGENS ON GRASSES

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Two samples of stem rust on *Elymus scabrus* (*Agropyrum scabrum*) collected from Qld in October and November failed to yield a viable rust isolate. Samples of leaf rust on a range of grasses did not infect a range of standard differential genotypes of wheat, barley, oats and cereal rye in our greenhouse tests, indicating that the rust present was either not viable or not a cereal attacking rust pathogen. The samples were:

- one sample of leaf rust on *Phalaris* sp. forwarded from Cowra southern NSW in May
- one sample of leaf rust on barley grass from Queensland collected in November
- a single sample of stem rust on rye grass collected in WA in February 2009, presumably the pathogen present was *P. graminis* f. sp. *lolli*
- single samples of leaf rust on unidentified grass species from WA (November), northern NSW (September) and Queensland (August).

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Table 1. Wheat stem rust isolates identified by region, 1 April 2008 - 31 March 2009

	Number of Isolates							
	Region 1	Region 2	Region 3	Region 4		Region 5	Region 6	
Pathotype	QLD	NNSW	SNSW	VIC	TAS	SA	WA	**TOTAL**
34-1,2,7 +Sr38	2	4	-	-	-	-	24	**30**
34-1,2,7 +Sr38 Yalta low		1	-	-	-	-	2	**3**
34-2,12,13	3	1	-	-	-	-		**4**
98-1,2,3,5,6	1	-	-	-	-	-	1	**2**
98-1,2,3,5,6,7							12	**12**
343-1,2,3,5,6	10	-	-	-	-	-	11	**21**
222-1,2,3,5,6,7	1	-	-	-	-	-	2	3
Total no isolates	**17**	**6**	**0**	**0**	**0**	**0**	**52**	**75**
Total no samples	**15**	**4**	**0**	**0**	**0**	**0**	**40**	**59**
No failed samples	3	0	0	0	0	0	9	**12**

Table 2. Wheat leaf rust isolates identified by region, 1 April 2008 – 31 March 2009

	Number of Isolates							
	Region 1	Region 2	Region 3	Region 4		Region 5	Region 6	
Pathotype	QLD	NNSW	SNSW	VIC	TAS	SA	WA	**TOTAL**
10-1,3,9,10,11,12	-	-	2	-	-	-	-	**2**
76-1,3,5,9,10,12	1	1	-	-	-	-	-	**2**
76-3,5,9,10 +Lr37	-	5	2	-	-	-	-	**7**
76-3,5,9,10,12 +Lr37	-	1	-	-	-	-	-	**1**
104-1,2,3,(6),(7),11	3	3	-	-	-	-	1	**7**
104-1,2,3,(6),(7),11 +Gaza high							1	**1**
104-1,2,3,(6),(7),11 +Lr37	3	9	1	1	-	-	1	**15**
104-1,2,3,(6),(7),11,13	3		1	2	-	-	-	**6**
Total no isolates	**10**	**19**	**6**	**3**	**0**	**0**	**3**	**41**
Total no samples	**8**	**11**	**4**	**2**	**0**	**0**	**2**	**27**
No failed samples	1	1	0	0	0	0	0	**2**

Table 3. Stripe rust isolates identified by region, 1 April 2008 – 31 March 2009

	Number of Isolates							
	Region 1	Region 2	Region 3	Region 4		Region 5	Region 6	
Pathotype	QLD	NNSW	SNSW	VIC	TAS	SA	WA	**TOTAL**
134 E16 A+	43	69	38	8	1	7	6	**172**
134 E16 A+ Yr17+	21	36	43	4	-	1	-	**105**
134 E16 A+ J+	61	92	250	54	5	19	-	**481**
134 E16 A+ J+ Yr27+	-	2	-	1	-	-	-	**3**
Miscellaneous	3	4	2	-	-	-	-	**9**
BGYR	1	7	7	-	-	2	-	**17**
Total no isolates	**129**	**210**	**340**	**67**	**6**	**29**	**6**	**787**
Total no samples	**139**	**229**	**357**	**71**	**7**	**30**	**7**	**840**
No failed samples	10	18	17	4	1	1	1	**52**

Table 4. Oat stem rust isolates identified by region, 1 April 2008 – 31 March 2009

	Number of Isolates							
	Region 1	Region 2	Region 3	Region 4		Region 5	Region 6	
Pathotype	QLD	NNSW	SNSW	VIC	TAS	SA	WA	**TOTAL**
94-2	-	2	1	-	-	-	2	**5**
94-3	-	-	1	-	-	1	1	**3**
94-2,3	-	5	3	-	-	1	-	**9**
94-2,4	5	1	-	-	-	-	-	**6**
94-3,4	3	2	1	-	-	-	-	**6**
94-2,3,4	7	5	-	-	-	1	-	**13**
Total no isolates	**15**	**15**	**6**			**3**	**3**	**42**
Total no samples	**13**	**11**	**6**			**2**	**2**	**34**
No failed samples		1	1					**2**

Table 5. Oat crown rust isolates identified by region, 1 April 2008 – 31 March 2009

	Number of Isolates							
	Region 1	Region 2	Region 3	Region 4		Region 5	Region 6	
Pathotype	QLD	NNSW	SNSW	VIC	TAS	SA	WA	**TOTAL**
0000-0	-	-	1	-	-	-	-	**1**
0000-2	-	1	-	-	-	2	-	**3**
0001-0	3	9	3	-	-	1	1	**17**
0001-0 +Pc92	-	-	-	-	-	-	4	**4**
0001-0 +Saia	-	-	-	1	-	-	-	**1**
0003-6,10	-	-	1	-	-	-	-	**1**
0007-4,6,8,10 +Nugene	-	3	1	-	-	-	-	**4**
0107-4,6,10	1	-	-	-	-	-	-	**1**
0107-4,6,10 +Nugene	5	2	-	-	-	-	-	**7**
0107-4,6,10 +Warrego	1	1	-	-	-	-	-	**2**
0107-4,6,10 +Warrego +Nugene	7	5	-	-	-	-	-	**12**
0107-6,10 +Warrego +Nugene	1	-	-	-	-	-	-	**1**
0307-3,4,5,6,10 +Warrego +Volta	11	3	-	-	-	-	-	**14**
0307-4,5,6,10	1	-	-	-	-	-	-	**1**
0307-4,5,6,10 +Nugene	2	4	-	-	-	-	-	**6**
0307-5,6,10 +Nugene	1	-	-	-	-	-	-	**1**
0767-3,4,5,6,10 +Warrego +Volta	1	-	-	-	-	-	-	**1**
2007-4,6,10 +Nugene	1	1	-	-	-	-	-	**2**
2007-6,8,10 +Nugene	1	3	2	-	-	-	-	**6**
2207-4,5,6,10	-	2	-	-	-	-	-	**2**
0071-0	-	2	3	-	-	-	-	**5**
0071-1,4,7,12 +Gwydir	1	1	-	-	-	-	-	**2**
0071-4	1	4	1	-	-	1	-	**7**
4473-4,6,10	2	2	-	-	-	-	-	**4**
4473-4,6,10 +Bettong +Barcoo	3	6	-	-	-	-	-	**9**
Total no isolates	**43**	**49**	**12**	**1**	**0**	**4**	**5**	**114**
Total no samples	**20**	**19**	**7**	**2**	**0**	**3**	**5**	**56**
No failed samples	2	1	1	1	0	0	0	**5**
Samples from cultivated oats	15	4	4	2	0	0	5	**30**
Samples from wild oats	5	15	3	0	0	3	0	**26**

Table 6. Barley stem rust isolates identified by region, 1 April 2008 – 31 March 2009

	Number of Isolates							
	Region 1	Region 2	Region 3	Region 4		Region 5	Region 6	
Pathotype	QLD	NNSW	SNSW	VIC	TAS	SA	WA	**TOTAL**
34-1,2,7 +Sr38	-	1	-	-	-	-	4	**5**
Scabrum	1	-	-	-	-	-	-	**1**
Scabrum +Sr21	-	1	-	-	-	-	-	**1**
Total no isolates	**1**	**2**	**0**	**0**	**0**	**0**	**4**	**7**
Total no samples	**2**	**1**	**0**	**0**	**0**	**0**	**9**	**12**
No failed samples	1	0	0	0	0	0	5	**6**

Table 7. Isolates of *Puccinia hordei* identified by region, 1 April 2008 – 31 March 2009

	Number of Isolates							
	Region 1	Region 2	Region 3	Region 4		Region 5	Region 6	
Pathotype	QLD	NNSW	SNSW	VIC	TAS	SA	WA	**TOTAL**
5453P- (+PI366444)	4	2	-	-	-	-	5	**11**
5453P+ (+PI366444)	29	9	1	1	11	-	6	**57**
5453P+ (+PI366444) +Rph13	1	1	-	-	-	-	-	**2**
5473P+ (+PI366444)	-	1	-	-	-	-	-	**1**
5652P+	-	-	-	-	3	-	-	**3**
Total no isolates	**34**	**13**	**1**	**1**	**14**	**0**	**11**	**74**
Total no samples	**33**	**9**	**1**	**1**	**14**	**0**	**7**	**65**
No failed samples	3	0	0	0	2	0	0	**5**