Introduction
Since its discovery and characterization in western Canada in 1995, the significance and dissemination of post-weaning multisystemic wasting syndrome (PMWS) has grown and the syndrome is undoubtedly a serious issue in the global swine industry. More recently, there is a heightened interest in PMWS due to the explosive outbreaks in eastern Canada, particularly in Quebec and Ontario starting in late 2004.

PMWS is caused by Porcine Circovirus type 2 (PCV2), a small single stranded DNA virus. It is the only circovirus known to cause disease in mammals, but circoviruses cause numerous diseases in birds including chicken anemia virus and psitticine beak and feather disease. By contrast, porcine circovirus type 1 (PCV1) does not cause disease in pigs, and is genetically and antigenically distinct from PCV2. In additional to PMWS of swine, PCV2 contributes to porcine respiratory disease complex (PRDC) and proliferative and necrotizing pneumonia (PNP). It has also been associated with several other conditions including humpy-back swine, porcine dermatitis and nephropathy syndrome (PDNS), congenital tremors (CT-AII), pre-natal myocarditis and reproductive failure. It is important to note that PCV2’s involvement in these latter conditions has not been proven.

PCV2 infection is unmistakably necessary to cause PMWS (Krakowka et al., 2000; Kennedy et al., 2000; Bolin et al., 2001), yet the virus is ubiquitous and present in both diseased and healthy pig populations worldwide. Furthermore, serology collected from western and eastern Canadian farms in 1997/98 (Harding, 2000) demonstrated that PCV2 specific antibody levels among PMWS clinical and non-clinical herds were not significantly different. Clearly, the epidemiology and pathogenesis of the PCV2 associated diseases are complex and have challenged researchers, and made successful control programs challenging. However, there are several commercial vaccines awaiting Canadian registration that will substantially enhance on-farm control efforts.

Post weaning multisystemic wasting syndrome (PMWS)
There are several classic clinical signs of PMWS that form the basis of a preliminary clinical diagnosis. From most to least common these are enlarged lymph nodes, wasting, dyspnea, diarrhea, pallor, and jaundice (Harding et al., 1998a & 1998b; Cottrell et al., 1999; Harms, 1999a). While all of these signs will not be noted in a single pig, affected farms will present with the majority, if not all, over a period of time. Other clinical signs including coughing, fever, gastric ulceration, meningitis and sudden death have also been reported, but are less prevalent (Harms, 1999a; Wellenberg et al., 2000). Some may be caused in part or exacerbated by secondary infections, as PCV2 appears to be immunosuppressive.

The clinical signs of PMWS are traditionally restricted to the post-weaned aged groups, but particularly the late nursery and early grower stages, typically affecting pigs between 7 and 15 weeks of age (Harding et al., 1998b). Ironically, the 2004/05 Quebec outbreak appears to preferentially affect older finisher hogs; the reasons for which are not entirely clear. Before 2005, PMWS in North America caused low grade but persistent death losses. On rare occasion, severe epidemics resulting in substantially higher post-weaning mortality rates occurred. Persistent, high mortality has been noted commonly in Europe over the last decade. Ironically, it
is likely that the same is happening at present in Canada after an 8-year period of quiescence. As such, I predict a slow progression of the severe clinical disease from eastern to western Canada, over the next 12-24 months. The reasons for the sudden explosive outbreaks in specific geographic regions are unknown. Current theories include the mutation of PCV2 into more virulent strain(s), the presence of a non-PCV2 but infective cofactor (Agent X), or changes in farm management that “trigger” the onset of disease. The latter is supported by the knowledge that certain vaccines adjuvants induce PMWS under experimental and some field conditions (Allan et al, 2000).

The case fatality rate of clinically affected pigs is typically high, particularly in the early stages of the outbreak, but mortality can be lowered by the implementation of good management and therapeutic practices (Madec et al., 2000). Maintaining ideal pen density, age segregation and all-in-all-out pig flow with the timely removal of sick animals is widely recommended, as well as the review of vaccination usage plans. Preliminary in vitro studies on disinfectants demonstrate that many commonly used products are ineffective (Royer et al., 2000), which is consistent with our knowledge that other circoviruses are highly resistant to inactivation by detergents and disinfectants.

**Porcine Dermatitis and Nephropathy Syndrome (PDNS)**
Porcine dermatitis and nephropathy syndrome is an immune-mediated vascular disease affecting the skin and kidney, originally described in the UK (Smith et al., 1993; White and Higgins, 1993). The most common clinical signs are the development of round or irregular shaped, red to purple skin lesions that coalesce to larger patches and plaques. The lesions are usually first noted in the hindquarters, limbs and abdomen but may progress to involve the thorax, flank or ears. Mildly affected animals may remain bright, alert and most often spontaneously recover. They do not generally have a fever. Severely affected animals may demonstrate lameness, fever, anorexia, or weight loss. Sudden death occurs but is rare. The characteristic lesion of PDNS is a systemic necrotizing vasculitis of the skin and kidneys. Grossly, the kidneys are enlarged, pale and often covered with small petechial haemorrhages. Microscopic lesions are characteristic of a type 3 hypersensitivity, immune mediated disorder caused by the deposition of immune complexes in the vascular and glomerular capillary walls (Duran et al., 1997; Drolet et al., 1999).

PDNS affects nursery and grow-finish pigs and is generally sporadic (Thompson et al., 2000; Gresham et al., 2000). While a significant problem in Europe, PDNS is infrequent in Canada, but appears to be farm specific supporting the theory that PDNS is genetic-line dependent. There is a link between PDNS and PCV2; PCV2 antigen and/or nucleic acid has been found in the tissues of pigs with PDNS (Rosell et al., 2000) and has also been found associated with kidney lesions of affected pigs (Clark, unpublished). PDNS must be considered in the diagnostic investigation of pigs with skin and kidney lesions, especially skin diseases caused by *Erysipelothrix rhusiopathiae* and *Actinobacillus suis*.

**Pre-natal Myocarditis and Reproductive Failure**
The involvement of PCV2 in reproductive failure is most common in start up herds (Sanford, 2002), but is not a consistent finding in PMWS outbreaks. Following the original reports of PCV2 associated reproductive failure in 2 western Canadian herds in 1999 (West et al, 1999; O’Connor et al., 2001), similar reports have been made Iowa, and western Europe (Ohlinger et al., 2000; Janke, 2000). Affected farms reported abortions, and elevated stillbirth and fetal mummification rates with variable amounts of PCV2 antigen present in fetal tissues, and in the cardiac lesions of affected piglets with myocarditis. PCV2 infection is also suspected in PMWS outbreaks of CDCD piglets (Jolie, et al., 2000; Harms et al., 1999b), further suggesting that
vertical transmission is possible. Currently, scientists believe that that reproductive disease associated with PCV2 is rare and that vertical transmission may not be a primary mechanism for disease dissemination. However, it has recently been reported that boars can shed PCV2 in semen for extended periods (McIntosh, 2005), and anecdotal field evidence supports a potential role of vertical transmission of PCV2 in some farms.

**PCV2 Vaccines**
At the time of writing, there are no licensed vaccines in the North American market, although several pharmaceutical companies have products in their pipeline. Public domain research documenting the efficacy of these experimental vaccines is limited, but the experimental and field research available is promising (Charreyre, 2005; Meng, 2005). The products under development are targeted at both the breeding herd, to enhance the passive immunity of piglets, and feeding herd, to initiate active immunity post-weaning. Both killed and attenuated live vaccines are under development. The use of autogenous vaccines has been suggested, however it is unlikely that autogenous PCV2 vaccines would be effective, and more importantly may not be safe, because PCV2 is difficult to grow in tissue culture, and is very resistant to inactivation.

**Summary**
Our understanding of the factors affecting the emergence and severity of PMWS on affected farms is lacking, as is a complete understanding of the epidemiology and potential triggering factors. The pattern of antibody development demonstrates that PCV2 actively circulates in farrow to finish farms in the early post-weaning stages (nursery, early grower) and that horizontal transmission is significant. The presence of PCV2 antibody in non-clinical herds clearly indicates that PCV2 by itself is not capable of causing severe clinical disease yet PCV2 is absolutely required for PWMS infection. The potentiation of PMWS by co-infection with porcine parvovirus and PRRS virus has been proven experimentally (Krakowka et al., 2000; Kennedy et al., 2000; Harms et al., 2000) and is very likely a phenomenon in the field. Until vaccines are readily available in the Canadian industry, producers should enhance the biosecurity of their unit to minimize the risk of regional spread, and should limit the purchase of semen and/or live animals from countries and regions that have experienced epidemic outbreaks.

**References**


McIntosh KA, Harding JCS, Ellis JA, Appleyard GD. Nested PCR detection and duration of porcine circovirus type 2 in semen from naturally infected boars. Proc International Conf Animal Circoviruses and Associated Diseases, Belfast, Ireland, Sept 11-13, 2005:p93.


