Le pathogène *E. coli* O157:H7 nouvellement détecté chez des porcs en Ontario et aux États-Unis

Mémoire déposé à la

Commission sur le développement durable
de l'industrie porcine au Québec

par

l'Amicale botanique du grand Rigaud

5 mai 2003

TABLE DES MATIÈRES

Préambule

I. LE PATHOGÈNE *E. COLI* O157:H7 NOUVELLEMENT DÉTECTÉ CHEZ DES PORCS EN ONTARIO ET AUX ÉTATS-UNIS

L'étude américaine
L'étude ontarienne
Risque de contamination environnementale
Persistance d'*E. coli* O157:H7
Résistance à des antibiotiques
Nouvelles connaissances – Nouvelles inquiétudes

Recommandations

II. GÉNÉRALITÉS

Recommandations

ANNEXES (articles cités)

- "E. coli 0157 found in U.S. hogs"
- "Isolation of *Escherichia coli* O157:H7 from Intact Colon Fecal Samples of Swine"
- "Disease Prevalence Exceeds Expectations"
- "New test finds some on-farm E. coli"
- "Finding the bacterial needle in the haystack"
- "Pigs linked to E. coli infection: Hog farms not immune to Walkerton strain, researchers find"
- "Nutrient legislation omits threat of pathogens to groundwater"

I. PRÉAMBULE

Notre organisme

L'Amicale botanique du grand Rigaud est un organisme communautaire local créé en avril 2001 et qui regroupe aujourd'hui quelque 75 membres.

Ses objectifs, connexes à celui de promouvoir l'intérêt pour l'horticulture, sont de :

- favoriser l'intérêt et l'action pour la préservation de l'environnement,
- et réaliser des activités locales à caractère horticole et environnemental.

Nos préoccupations devant l'industrie porcine et son expansion

Notre organisme et plusieurs de ses membres sont préoccupés par l'industrie porcine parce que sa récente expansion, au Québec, s'est faite sans égard à des enjeux et valeurs que nous considérons cruciaux :

- l'environnement rural,
- la santé humaine,
- la cohabitation en milieu rural,
- le développement agricole durable,
- le droit fondamental des citoyens à l'information,
- les principes de la démocratie et de la transparence,
- le principe de précaution.

Notre mémoire

Nous nous sentons responsables de déposer ce mémoire car nous avons découvert des articles scientifiques qui ne semblent pas avoir été portés à la connaissance de votre Commission, ni à l'attention du ministère de la Santé et des Services sociaux car il n'en a pas fait mention dans son *Mémoire de santé publique* d'avril 2003.

I. LE PATHOGÈNE *E. COLI* O157:H7

NOUVELLEMENT DÉTECTÉ CHEZ DES PORCS

EN ONTARIO ET AUX ÉTATS-UNIS

Le purin contaminé peut infecter le sol, l'eau et les légumes

L'information résumée ci-dessous aurait certainement déjà fait la manchette si ce n'eût été d'autres événements marquants qui ont détourné l'attention des médias.

Notamment au Québec, en pleine audience publique du BAPE sur la production porcine, nous nous expliquons mal que ces faits n'aient pas été signalés.

Même le ministère de la Santé et des services sociaux du Québec ne semble pas en avoir pris connaissance : dans son *Mémoire de santé publique*, il affirme à tort que :

> les souches de *E. coli* retrouvées chez le porc n'appartiennent pas aux espèces pouvant produire des toxines comme celle ayant causé des décès à Walkerton.[1]

En réalité :

- **Deux équipes de recherche scientifique ont récemment détecté, chez des porcs en Ontario et aux États-Unis, des souches de la bactérie *E. coli* O157:H7 pouvant produire des toxines.**

- **Dans les deux cas, c'est le type *d'E. coli* toxique qui, à Walkerton (Ontario) en mai 2000, après un épandage de fumier (bovin) dans un champ, s'est retrouvé dans l'eau potable et a causé 7 décès et 1 346 intoxications (représentant 30% de la population du village).**

- **L'étude américaine est rapportée dans le très sérieux bulletin *Emerging Infectious Diseases* des Centers for Disease Control (CDC).**

- **L'étude canadienne (Université de Guelph) qui a fait pareille découverte dans des fermes porcines en Ontario, ne semble pas terminée. Malgré l'absence d'article de revue scientifique à son sujet, à ce stade, des données préliminaires viennent d'être mentionnées dans la revue *Ontario Farmer.***

Les textes intégraux d'où nous avons tiré l'information sont copiés en annexe à notre mémoire, avec les liens Internet directs. Voici un résumé en français de certains passages que nous croyons important de mettre en relief.

---

[1] Ministère de la Santé et des Services sociaux, « Mémoire national de santé publique présenté à la Commission sur le développement durable de la production porcine au Québec », avril 2003, p. 10.

L'étude américaine – L'intestin de 2% des porcs étudiés dans un abattoir américain contenait des variétés toxiques de la bactérie *E. coli* O157:H7. L'équipe scientifique dirigée par la D^re^ Ingrid Feder, microbiologiste au ministère américain de l'Agriculture, est la première à avoir découvert ce type de bactérie chez des porcs aux États-Unis.[2]

D'autres chercheurs l'avaient détectée précédemment dans des fèces de porcs au Japon, en Norvège et au Chili, signalent les auteurs de l'étude. [Le Canada s'ajoute à cette liste, dès le bas de cette page.]

L'étude américaine a détecté, dans des fèces parmi les 305 porcs échantillonnés au hasard, deux génotypes qui « devraient être considérés comme potentiellement pathogènes pour l'humain ». Deux gènes responsables de la toxine *Shiga* (stx1 et stx2) ont été décelés dans des échantillons. Les Centers for Disease Control estiment que l'*E. coli* O157:H7 cause en moyenne 500 flambées épidémiques – touchant plus de 73 000 personnes et causant quelque 61 décès, chaque année aux États-Unis.

Les échantillons positifs ont été soumis à des tests de susceptibilité à 17 agents antimicrobiens; un d'entre eux était résistant à la streptomycine.

Les chercheurs croient qu'il y a eu transmission du pathogène entre porcs, mais ils n'ont pu établir si cela s'était produit à la ferme d'origine, ou plutôt lors du transport ou dans le parc d'attente à l'abattoir.

L'étude ontarienne – Des recherches semblables en Ontario ont aussi permis de déceler la variété toxique d'*E. coli* O157:H7 chez des porcs – dans 3 fermes porcines sur 44 qui ont été examinées.[3] Dans un article publié par un magazine porcin, on signale que cette découverte est une première au Canada. L'étude est dirigée par le Dr Carlton Gayle, de l'Université de Guelph, en collaboration avec Santé Canada.

L'article précise que le type *d'E. coli* détecté portait un gène responsable de la toxine *Shiga*. Le professeur Carlton Gyles, microbiologiste à Guelph, a expliqué que « même une faible concentration pourrait s'avérer dangereuse si elle se trouve dans des millions de litres de purin »[4] comme en entreposent les méga-porcheries avant de les épandre aux champs. Gyles a précisé : « Si [les cochons] excrètent cet organisme, l'environnement peut certainement en être contaminé. » Dans une autre entrevue, il a précisé : « Là où il a été trouvé, *l'E.* coli O157:H7 était en quantité estimée à 1 000

---

[2] Feder I. et coll., « Isolation of *Escherichia coli* O157:H7 from Intact Colon Fecal Samples of Swine », *Emerging Infectious Diseases*, mars 2003, vol. 9, no3, p. 8. (www.cdc.gov/ncidod/EID/vol9no3/02-0350.htm)

[3] « 2002 Research Update : Disease Prevalence Exceeds Expectations », *National Hog Farmer – The Pork Business Authority*, janvier 2003. (http://nationalhogfarmer.com/ar/farming_herd_health_management/index.htm)

[4] Tom Spears, Pigs linked to E. coli infection : Hog farms not immune to Walkerton strain, researchers find », *Ottawa Citizen*, 26 novembre 2002. (www.creekwebsite.org/NewsItems/year2003/news03028.htm)

organismes par gramme de fèces. Même si cela est considéré comme un nombre relativement faible, il est important puisque l'on parle d'un coliforme qui a causé des infections à partir d'aussi peu que de 10 à 100 organismes. »[5]

Tout récemment, la revue *Ontario Farmer* a rapporté des données plus précises de cette même étude qui se poursuit. On rapporte que l'équipe de Guelph a prélevé des échantillons de fèces de 15 porcs, dans chacune des 44 fermes à l'étude.[6]

Dans l'une des trois fermes où l'on a détecté la variété toxique d'*E. coli* O157:H7, douze (12) des quinze (15) porcs échantillonnés en étaient porteurs [80%]; dans une autre des fermes, 7 des 15 porcs en étaient porteurs.

L'article d'*Ontario Farmer* précise : « À tout le moins, la découverte devrait alerter les éleveurs de porcs et les inciter à faire très attention à épandre le purin de manière à ce qu'il ne contamine pas l'eau potable. »

Risque de contamination environnementale – L'Association américaine des vétérinaires porcins prévient : « Les déjections animales porteuses d'*E. coli* O157:H7 peuvent infecter le sol, les eaux et les aliments. »[7]

Une lacune réglementaire semble susceptible de catalyser cette possibilité : les réglementations axées sur la gestion des éléments nutritifs reposent sur des critères agronomiques qui ne sont pas nécessairement adéquats au contrôle des pathogènes. Notamment, dans un autre article récent de la revue *Ontario Farmer,* on discute de cette problématique en rapport avec la *Loi sur la gestion des éléments nutritifs* en Ontario (le commentaire semble être tout aussi pertinent aux règlements du Québec sur la gestion du phosphore) :

> Les règlements sur la gestion des éléments nutritifs ne parlent pas de pathogènes. … [On] prend pour acquis que lorsque les agriculteurs règleront les deux problèmes nommés dans le programme de gestion – l'azote et le phosphore –, la quantité de pathogènes à atteindre les eaux serait également réduite. Ce n'est pas nécessairement le cas, d'après le Dr. Michael Goss, de l'Université de Guelph … [qui] affirme que l'azote et les pathogènes coulent parfois vers les eaux potables de manières différentes. Par exemple, l'azote tend à infiltrer davantage les sols à texture grossière, comme le sable et le gravier, vers les eaux souterraines. … En revanche, les pathogènes semblent voyager plus facilement dans des sols à texture fine (e.g. l'argile) vers l'eau souterraine … Goss note qu'entre les tests de puits des années 1950 et ceux des années 1990 … l'incidence de bactéries néfastes a doublé. … [Il] croit que

---

[5] Ken Bennett, « Finding the bacterial needle in the haystack », *Better farming,* avril 2002, archivé sur le site d'Agriculture et agro-alimentaire Canada (http://res2.agr.ca/initiatives/manurenet/en/fpress_archive.html) téléchargement: <http://res2.agr.ca/initiatives/manurenet/archive/bf_apr_2002.pdf>.

[6] Jim Romahn, « New test finds some on-farm E. coli », *Ontario Farmer,* 18 mars 2003, archivé sur le site d'Agriculture et agro-alimentaire Canada. (http://res2.agr.ca/initiatives/manurenet/en/fpress_archive.html) téléchargement <http://res2.agr.ca/initiatives/manurenet/archive/of030318.pdf>.

[7] Michael Meredith, « E coli 0157:H7 found in US hogs », American Association of Swine Veterinarians News, 5 mars 2003. (www.aasp.org/news/story.php?id=494)

> la différence réside dans l'introduction des systèmes de gestion liquide des fumiers. … Le purin est plus susceptible de s'infiltrer dans les tunnels des vers, les pores et les fissures dans le sol.[8]

Persistance *d'E.* coli O157:H7 – Un rapport du ministère de l'Agriculture du Manitoba[9] signale que la bactérie *E. coli* O157:H7 peut survivre de longues périodes dans divers milieux et conditions. D'après les données du ministère, elle peut vivre plus de 300 jours dans une eau froide (5˚C), dans la glace ou dans un sol gelé. Dans un sol à 5˚C ou dans du purin de porc, elle peut vivre jusqu'à 100 jours. (En revanche, la bactérie ne survivrait que sept jours dans du compost de fumier *solide*.)

Résistance à des antibiotiques Le D[r] Gavin Hamilton, dans une lettre au journal *London Free Press*,[10] lançait de sérieux avertissements à propos de l'usage répandu d'antibiotiques dans l'élevage industriel de porcs. Il rappelle que l'*E. coli* qui a frappé le village de Walkerton était résistant aux antibiotiques à cause du mélange d'antibiotiques intégré dans l'alimentation des animaux d'élevage, même sains, à titre préventif, ou comme stimulant de la croissance malgré la recommandation émise contre cette pratique, en 1997, par l'Organisation mondiale de la santé.

Le D[r] Hamilton explique que le purin contient non seulement des résidus d'antibiotiques, mais aussi potentiellement des pathogènes qui ont survécu à ces doses sous-thérapeutiques de médicaments et qui ont développé des gènes de résistance.

Il mentionne, de plus, « deux découvertes récentes et effrayantes. Les racines de certaines plantes peuvent aspirer ces organismes mortels vers la structure interne de plantes comestibles. Et les gènes de résistance aux antibiotiques peuvent se transférer d'un type de bactérie à un autre. Cela signifie que dans le purin ou dans les eaux (rivières, nappe phréatique etc.) la résistance à des antibiotiques peut être transférée d'un *E. coli* à une *salmonelle*, ou vice versa. »

Nous n'avons pas les ressources pour fouiller cette vaste problématique, mais nous considérons que ce phénomène rend l'ensemble du dossier des pathogènes encore plus préoccupant.[11]

---

[8] Jim Romahn, « Nutrient legislation omits threat of pathogens to ground water », *Ontario Farmer*, 18 mars 2003, archivé sur le site d'Agriculture et agro-alimentaire Canada. (http://res2.agr.ca/initiatives/manurenet/en/fpress_archive.html) téléchargement <http://res2.agr.ca/initiatives/manurenet/archive/of030318.pdf>.

[9] *Livestock Pathogens : A natural Occurrence*, Manitoba Agriculture and Food, tableau 1 (adapt. De M. Olson, University of Calgary), juin 2002. (www.gov.mb.ca/agriculture/livestock/publicconcerns/cwa01s11.html)

[10] Dr Gavin Hamilton, « Improper Antibiotic Use Endangers Us All », *Keep Antibiotics Working*, 25 mars 2003. (www.keepantibioticsworking.com/News/News.cfm?news_ID=281)

[11] Nous nous permettons de référer votre Commission au *Rapport du Comité consultatif sur l'utilisation d'antimicrobiens chez les animaux et les conséquences pour la résistance et la santé humaine*, préparé pour la Direction des médicaments vétérinaires, Santé Canada Juin 2002 (accessible via www.hc-sc.gc.ca/vetdrugs-medsvet/amr_final_report_june27_cp_f.html.)

NOUVELLES CONNAISSANCES – NOUVELLES INQUIÉTUDES

Nous sommes consternés par le fait que ces informations importantes semblent être passées inaperçues lors des audiences publiques.

- Le MSSSQ n'était-il pas au fait de ces révélations scientifiques?
- Les intervenants de l'industrie porcine le sont-ils? Sinon, cela est encore plus inquiétant – comment réagir adéquatement sans être conscient du risque?
- Qu'ignore-t-on de la situation possible des porcs québécois en regard d'E. coli O157:H7?

RECOMMANDATION 1

Informer le secteur porcin ainsi que les ministères québécois de ces découvertes.

RECOMMANDATION 2

Examiner la possible présence d'*E. coli* O157:H7 dans le cheptel porcin québécois.

Ne perdons pas de vue que sur le terrain, même en cette période de moratoire à l'*expansion* porcine, le Québec produit plusieurs millions de porcs par année; que des millions de litres de purin sont épandus aux champs; et que le ruissellement et l'infiltration des nappes phréatiques ne connaissent pas de moratoire.

→ En tant qu'organisme qui regroupe des jardiniers, nous savons pertinemment, pour l'avoir vu, que **plusieurs propriétaires riverains pompent ou puisent de l'eau de rivières qui longent leur propriété, pour arroser leurs jardins – y compris potagers.**

Certains de nos membres le font et nous avons observé la même pratique lors de visites dans d'autres régions, notamment dans la région de Saint-Esprit où l'on compte de nombreuses porcheries. La pratique est probablement assez répandue, *a fortiori* en période de sécheresse, alors qu'il n'est pas inimaginable que précisément les concentrations bactériennes en rivière soient plus élevées.

Jusqu'ici, les producteurs porcins semblent avoir fréquemment souligné que le type O157:H7 de *l'E.* coli ne se rencontrait pas chez le porc.

Ayant désormais la preuve du contraire, il faut rectifier l'information.

RECOMMANDATION 3

Informer le grand public de la possible présence d'*E. coli* O157:H7 dans les rivières en aval de porcheries et dans les puits voisins de champs épandus. Préciser la durée de vie possible de la bactérie dans le purin, les eaux et le sol ainsi que son absorption possible dans des légumes, le cas échéant. Recommander les mesures préventives adéquates.

RECOMMANDATION 4

Mettre à jour les critères d'études portant sur la résistance aux antimicrobiens dans les fèces de porcs au Québec, afin d'y inclure la surveillance de l'*E. coli* O157:H7 et de sa possible résistance aux antimicrobiens d'usage courant.

RECOMMANDATION 5

Appliquer le principe de précaution le plus sérieusement possible, vu la preuve éloquente d'un fait clair : on en sait bien souvent moins que l'on veut le croire.

II. GÉNÉRALITÉS

En complément au contenu plus particulier de notre mémoire, nous souhaitons exprimer quelques considérations et propositions plus générales.

RECOMMANDATION 6

Prolonger le moratoire dans toutes les régions.

Devant l'ampleur de la tâche de mieux gérer l'industrie porcine actuelle ainsi que son expansion, nous considérons que le Gouvernement du Québec devrait prolonger le moratoire actuel qui bannit l'expansion de l'industrie porcine. En effet, entre le dépôt du rapport de votre Commission et les dates prévues d'expiration du moratoire actuel (décembre 2003 et juin 2004), il n'y aura probablement pas assez de temps, selon notre perception de la gravité de la situation et de la complexité des enjeux, pour la mise en œuvre des nombreuses solutions requises.

C'est pourquoi nous proposons que le moratoire soit prolongé – et non seulement dans les régions déclarées « en surplus de phosphore », mais également dans les régions encore épargnées et où il importe de protéger la population et le milieu contre les effets déplorables des pratiques et de l'insuffisance des normes actuelles pour gérer cette production qui se démarque de l'agriculture « normale » par un caractère intensif prononcé, jamais vu au Québec. Il est crucial d'arriver à une gestion appropriée, par des solutions novatrices et un virage majeur. Cela nécessitera forcément un temps considérable.

RECOMMANDATION 7

Intervenir pour prévenir et gérer la pollution porcine transfrontalière Ontario-Québec.

Nous exprimons notre accord avec toutes les positions et recommandations que vous a présentées le Groupe régional pour l'eau, la terre et l'air (GRETA), quant à la nécessité de prendre des mesures pour prévenir et gérer la pollution transfrontalière d'une éventuelle implantation de méga-porcheries dans l'Est ontarien.

Depuis le dépôt du mémoire du GRETA à votre Commission (en mars 2003), d'autres projets de méga-porcheries sont en préparation dans l'Est ontarien. Nous espérons grandement que votre Commission incitera le gouvernement du Québec à s'assurer de protéger les intérêts sanitaires et environnementaux des citoyens de sa région frontalière du Sud-ouest.

ANNEXES

Nous nous permettons de surligner certains passages pour faciliter le repérage d'information jugée cruciale.

• • •

E. coli 0157 found in U.S. hogs

March 5, 2003 — Michael Meredith, American Association of Swine Veterinarians
http://www.aasp.org/news/story.php?id=494

Escherichia coli O157:H7 has been recovered from the intestinal contents of 2% of 305 swine sampled at a United States abattoir. Polymerase chain reaction confirmed two genotypes, both considered potentially pathogenic to humans.

Previous attempts to isolate E. coli O157:H7 from swine feces in the United States have been unsuccessful but this study used improved techniques for sampling, processing, and culturing. The difficulty in isolating E. coli O157 from swine feces may in part be attributable to differences in the physiologic environment between swine and cattle feces.

The recovery rates for E. coli O157:H7 from swine in this study were similar to recovery rates in Japan. In Norway, the recovery rate (0.1%) of E. coli O157:H7 from pig feces was much lower. The organism has also been isolated from swine feces in Chile.

Escherichia coli O157:H7 has been an emerging infectious agent over the past two decades. The Centers for Disease Control and Prevention estimate that E. coli O157:H7 causes an average of 500 disease outbreaks that affect more than 73,000 persons and result in more than 61 deaths each year in the United States.

Farm animal manure contaminated with E. coli O157:H7 can infect soil, food, and water. Cattle feces are the most important source of E. coli O157:H7. Petting zoos have also infected some children.

Isolation of *Escherichia coli* O157:H7 from Intact Colon Fecal Samples of Swine(1)

Feder I, Wallace FM, Gray JT, Fratamico P, Fedorka-Cray PJ, Pearch RA, et al., *Emerging Infectious Diseases* [serial online] 2003 March; 8. http://www.cdc.gov/ncidod/EID/vol9no3/02-0350.htm

Escherichia coli O157:H7 was recovered from colon fecal samples of pigs. Polymerase chain reaction confirmed two genotypes: isolates harboring the *eaeA*, *stx*1, and *stx*2 genes and isolates harboring the *eaeA*, *stx*1, and *hly*933 genes. We demonstrate that swine in the United States can harbor potentially pathogenic *E. coli* O157:H7.

During the past two decades, disease caused by *Escherichia coli* O157:H7 has been increasing (1). Currently, the Centers for Disease Control and Prevention estimates that *E. coli* O157:H7 causes an average of 500 outbreaks that affect >73,000 persons and result in >61 deaths each year in the United States (2). The epidemiology of *E. coli* O157:H7 has become an important research topic as manure harboring *E. coli* O157:H7 is dispersed, and soil, food, and water are cross-contaminated with feces containing *E. coli* O157:H7 (1,3). Although cattle feces are the most important source of *E. coli* O157:H7, the need to evaluate the presence of *E. coli* O157:H7 in the feces of other animal species has been recognized (1). The presence of *E. coli* O157:H7 in swine feces has been reported in Japan (4), Norway (5), and Chile (6); however, to date, *E. coli* O157:H7 has not been reported in swine in the United States.

The Study

Colon samples were collected at a cooperating swine slaughter facility from 305 swine carcasses during evisceration. Two to three inches of distal colon that contained feces at the first point proximal to the rectum was resected and maintained on ice for approximately 2 hours before processing (Figure). Ten grams of feces from each colon was transferred to filter-lined sterile plastic bags. One hundred milliliters of brilliant green bile broth (Difco Laboratories, Detroit, MI), prewarmed to 37°C, was added to each filter stomacher bag containing feces and incubated at 37°C for 6 h with shaking (150 rpm) (7). After enrichment, 1.0-mL aliquots were processed by using Dynabeads anti–E. coli O157 (Dynal Biotech, Oslo, Norway), according to manufacturer's instructions with modification. Bead/sample suspensions were incubated at room temperature for 30 min with continuous mixing on a Bellco roller drum (Bellco Glass, Inc., Vineland, NJ) before plating onto sorbitol MacConkey (SMAC; Difco Laboratories), cefixime/tellurite (CT; cefixime-tellurite supplement, Dynal Biotech)-SMAC agars, and rainbow agar O157 (Biolog, Inc., Hayward, CA). Black colonies from rainbow agar O157 and sorbitol-negative colonies from CT-SMAC and SMAC agars were tested for the absence of ß-glucuronidase and the ability to ferment lactose by using E. coli broth containing 4-methylumbelliferyl-ß-D-glucuronide (MUG) (EC medium with MUG; Difco Laboratories) and MacConkey broth (Difco Laboratories), respectively. Lactose-positive/MUG-negative isolates were serotyped by using the RIM E. coli O157:H7 Latex Test (Remel, Lenexa, KS). Up to 10 E. coli O157 latex agglutination–positive isolates per colon fecal sample were tested for the presence of the rfbO157 gene by using polymerase chain reaction (PCR) (8). Isolates positive for the rfbO157 gene were further characterized for the presence of genes encoding the H7 flagellar protein (fliCH7), Shiga toxin 1 (stx1), Shiga toxin 2 (stx2), intimin protein (eaeA), and hemolysin (hly933) (9). We conducted further analysis using antimicrobial resistance patterns, pulsed-field gel electrophoresis (PFGE), and ribotyping on all E. coli O157 PCR–positive isolates containing fliCH7, stx1, stx2, eaeA, or hly933. However, for tabulation purposes, each sample ultimately contributed one isolate. When fliCH7, stx1, stx2, eaeA, or hly933 was not detected in PCR-confirmed E. coli O157 isolates, further analysis was performed on only one E. coli O157 isolate per colon sample.

E. coli O157 isolates were tested for susceptibility to 17 antimicrobial agents (amikacin, amoxicillin/clavulanic acid, ampicillin, apramycin, cefoxitin, ceftriaxone, cephalothin, chloramphenicol, ciprofloxacin, gentamicin, imipenem, kanamycin, nalidixic acid, streptomycin,

sulfamethoxazole, tetracycline, and trimethoprim/sulfamethoxazole) as described (10) by using a custom-made semiautomated broth microdilution assay (Sensititre, Trek Diagnostics, Westlake, OH). Imipenem was used at concentrations of 0.25–8.0 µg with the following breakpoints: sensitive (<4) and resistant (>16).

For PFGE, DNA was digested with 50 U XbaI (Invitrogen Corp., Carlsbad, CA) for 4 h at 37°C. PFGE was performed by using a CHEF Mapper XA system (Bio-Rad, Hercules, CA) at 14°C with pulses ramping from 2.16 s to 63.8 s over 18 h. PFGE patterns were evaluated visually, and isolates were assigned to the same pulsotype when exhibiting a difference of <3 bands from the index isolate. Ribotyping of the E. coli O157 isolates was done by using a RiboPrinter (Qualicon, Inc., Wilmington, DE) as described in the user's manual. Restriction digests were performed on E. coli O157 isolates by using the EcoRI enzyme (Qualicon, Inc.).

A total of 305 colon samples were randomly collected on 8 different days over a 6-month period as follows: collection day 1 (February 16, 2001), n=5; collection day 2 (March 8, 2001), n=20; collection day 3 (March 22, 2001), n=40; collection day 4 (April 20, 2001), n=40; collection day 5 (May 4, 2001), n=50; collection day 6 (May 16, 2001), n=50; collection day 7 (June 20, 2001), n=50; and collection day 8 (July 10, 2001), n=50 (Table). Eighteen (5.9%) of the 305 colon samples had isolates positive for rfbO157. Isolates from 6 of these 18 colon samples also contained fliCH7. Two gene combinations based on the presence or absence of stx1, stx2, eae, and hly933 were detected in these E. coli O157:H7 PCR-confirmed isolates. The stx1, eaeA, and hly933 virulence pattern was detected in two isolates (isolates 1 and 2) from two of the five colon samples collected on February 16, 2001, and the stx1, stx2, and eaeA virulence pattern was detected in 22 isolates (isolates 6–27) from 4 of the 50 colon samples collected on May 4, 2001. None of the E. coli O157:H7 isolates recovered contained all four of the virulence genes (stx1, stx2, eaeA, and hly933). None of the E. coli O157:non-H7 isolates (isolates 3–5, 28–36) in the present study contained stx1, stx2, eae, or hly genes. Non–Shiga toxin–producing E. coli O157:non-H7 isolates have been previously isolated from the feces of pigs (11,12). For slaughterhouse visits on March 8, March 22, June 20, and July 10, 2001, E. coli O157 and E. coli O157:H7 were not recovered from any of the colons sampled.

All E. coli O157:H7 isolates recovered in this study were sensitive to the antimicrobial agents tested, with the exception of one isolate (isolate 15) that was resistant to streptomycin. This isolate was recovered from a colon from which a pan-sensitive E. coli O157:H7 was also recovered. The antimicrobial sensitivity pattern of the E. coli O157:non-H7 isolates was more varied than that of the E. coli O157:H7 isolates with five different susceptibility patterns noted. Only one of the E. coli O157:non-H7 isolates was pan-sensitive. These data are similar to previous reports in which antimicrobial resistance among E. coli O157 non–Shiga toxin–producing isolates was higher than that of Shiga toxin–producing E. coli O157 isolates (11).

As previously shown, ribotyping did not discriminate among isolates within the E. coli O157:H7 serotype (13). Additionally, the E. coli O157:non-H7 isolates were indistinguishable from one another. Four PFGE profiles were noted. The E. coli O157:H7 isolates obtained from colon 1 and colon 2 on February 16, 2001, exhibited the PFGE type 1 pattern, whereas the E. coli O157:H7 isolates obtained from four colons on May 4, 2001 exhibited the PFGE type 2 pattern. The E. coli O157:non-H7 isolates obtained on April 20, 2001, and May 16, 2001, exhibited PFGE patterns 3 and 4, respectively.

Conclusions

Results from this study demonstrate that pigs in the United States can harbor E. coli O157:H7. The recovery rate of E. coli O157:H7 from colon fecal samples of pigs reported in this study was 2.0% (6/305). Previous attempts to isolate E. coli O157:H7 from swine feces in the United States have been unsuccessful (12,14). Use of more appropriate methods for sampling, processing, and culturing swine feces may have accounted for the ability to recover and isolate E. coli O157:H7 from swine feces in our study. For example, samples were obtained from the colon, transported on ice, and processed within 2 h of collection. The absence of antibiotics in our enrichment step may have also facilitated the recovery of E. coli O157:H7 from swine feces. Furthermore, although direct comparisons cannot be

made between cattle studies, the recovery rate of Shiga toxin–producing E. coli O157 from cattle feces has improved over the past 10 years. This is most likely due to more conducive sampling procedures, culture practices, and detection methods than an increase in true carriers. The detection of E. coli O157 in swine feces has previously been based on the isolation techniques used for the recovery of E. coli O157 from cattle feces. The difficulty in detecting E. coli O157 from swine feces may in part be attributable to differences in the physiologic environment between swine and cattle feces. More appropriate isolation techniques may still be discovered for detecting E. coli O157 in swine.

Although our recovery rates of E. coli O157:H7 from swine are similar to recovery rates in Japan (4), we recovered a genotype in addition to the stx1, stx1, and eaeA genotype: the stx1, eaeA, and hly933 genotype. In Norway, the recovery rate (0.1%) of E. coli O157:H7 from pig feces was much lower (5). Isolates recovered from Norway possessed the stx2 and eae genes only; however, the presence of the hly gene was not determined (5).

The ability to produce one or more Shiga toxins is an important virulence characteristic of E. coli O157:H7 (1). However, production of Shiga toxins alone may not be sufficient for E. coli O157:H7 to be pathogenic (1). Other virulence factors such as the intimin protein (involved in the attachment of the E. coli O157 to enterocytes), the presence of a plasmid-encoded hemolysin, or both, are important in the pathophysiology of hemorrhagic disease (1). E. coli O157:H7 isolates recovered in this study possessed either two virulence factors, eaeA and hly933, in addition to stx1 or one virulence factor, eaeA, in addition to stx1 and stx2. These isolates can potentially cause disease and should be considered pathogenic to humans. Since human E. coli O157:H7 clinical isolates contain the stx1, stx2, eaeA, and hly genes, the human pathogenicity of E. coli O157:H7 isolates from pigs that lack the hly gene requires further study.

The clonal nature of the isolates that were isolated on a particular day suggests transmission of E. coli O157 between pigs. Unfortunately, we did not have access to information concerning the source of the pigs from which the samples were collected, the number of pigs slaughtered from a given farm, or the holding facilities and grouping of the pigs before slaughter. Therefore, we do not know whether E. coli O157 transmission between pigs occurred on the farm, in transit, or while the pigs were in a holding pen at the slaughterhouse.

This study did not permit inferences of E. coli O157:H7 isolation rates with respect to the season, nor can inferences of E. coli O157:H7 isolation rates be made with respect to swine or herd prevalence. The relatively low recovery rate of E. coli O157:H7 from swine feces compared to cattle feces warrants further study to determine the significance and prevalence of E. coli O157:H7 in swine and if different enrichment and isolation methods would have an impact on the recovery of E. coli O157:H7 from swine feces. In addition, future studies should be conducted to determine the occurrence of E. coli O157 on swine hides, in swine mouths, and in swine stomachs.

Acknowledgments – We thank Connie Briggs and Lori Bagi for their technical support and assistance and Takiyah Ball and Jovita Hermosillo for their expertise in antimicrobial susceptibility testing.

Dr. Feder is a research microbiologist with the U.S. Department of Agriculture. Her research interests include diagnostic microbiology, molecular epidemiology, and assay development of zoonotic pathogens, primarily Escherichia coli O157:H7 and Salmonella.

References

1. Mead PS, Griffin PM. Escherichia coli O157:H7. Lancet 1998;352:1207–12.
2. Mead PS, Slutsker L, Dietz V, McCaig LF, Bresee JS, Shapiro C, et al. Food-related illness and death in the United States. Emerg Infect Dis 1999;5:607–25.
3. Charatan F. New York outbreak of E. coli poisoning affects 1000 and kills two. Br Med J. 1999;86:873.
4. Nakazawa M, Akiba M. Swine as a potential reservoir of Shiga toxin-producing Escherichia coli O157:H7 in Japan. Emerg Infect Dis 1999;5:833–4.
5. Johnsen G, Wasteson Y, Heir E, Berget OI, Herikstad H. Escherichia coli O157:H7 in faeces from cattle, sheep and pigs in the southwest part of Norway during 1998 and 1999. Int J Food Microbiol 2001;65:193–200.

6. Rios M, Prado V, Trucksis M, Arellano C, Borie C, Alexandre M, et al. Clonal diversity of Chilean isolates of enterohemorrhagic Escherichia coli from patients with hemolytic-uremic syndrome, asymptomatic subjects, animal reservoirs, and food products. J Clin Microbiol 1999:37;778–81.
7. Gray JT, Smith D, Moxley R, Rolfes C, Hungerford L, Younts S, et al. Comparison of oral and rectal sampling to classify the Escherichia coli O157:H7 status of pens of feedlot cattle. Program and abstracts of American Society for Microbiology annual meeting, May 21–22, Los Angeles, California. Washington: American Society for Microbiology; 2002:524–5.
8. Paton AW, Paton JC. Detection and characterization of Shiga toxigenic Escherichia coli by using multiplex PCR assays for stx1, stx2, eaeA, enterohemorrhagic E. coli hlyA, rfbO111, and rfbO157. J Clin Microbiol 1998;36:598–602.
9. Fratamico PM, Bagi LK, Pepe T. A multiplex polymerase chain reaction assay for rapid detection and identification of Escherichia coli O157:H7 in foods and bovine feces. J Food Prot 2000;63:1032–7.
10. Fedorka-Cray P. National antimicrobial resistance monitoring system annual report. Available from: http://www.ars-grin.gov/ars/SoAtlantic/Athens/arru/narms_2000/2000_tables/2000_table01.pdf
11. Schroeder CM, Zhao C, DebRoy C, Torcolini J, Zhao S, White DG, et al. Antimicrobial resistance of Escherichia coli O157 isolated from humans, cattle, swine, and food. Appl Environ Microbiol. 2002;68:576–81.
12. Feder I, Gray J, Pearce R, Fratamico P, Bush E, Wallace FM, et al. National animal health monitoring system swine 2000: a surveillance study of Escherichia coli O157 in swine. International Association for Food Protection annual meeting program and abstracts, June 29–July 3, 2001.
13. Martin IE, Tyler SD, Tyler KD, Khakhria R, Johnsen WM. Evaluation of ribotyping as epidemiologic tool for typing Escherichia coli serogroup O157 isolates. J Clin Microbiol. 1996;34:720–3.
14. Bush E. U.S. swine herd appears free of Escherichia coli O157:H7. Food Safety Digest 1997;4.

Disease Prevalence Exceeds Expectations

2002 Research Review, Jan 3 2003 (*National Hog Farmer*)
http://nationalhogfarmer.com/ar/farming_herd_health_management/index.htm

A random sampling of 100 pig farms in Ontario has revealed that some swine diseases are more commonly found in the Canadian province than were expected.

Surveys were conducted in the summers of 2001 and 2002. Blood samples were collected from sows and finisher hogs; manure samples were also taken from finishers. The University of Guelph is carrying out the project; results are still being analyzed.

Pigs were tested for pathogens of food safety concern, including salmonella, *E.* coli 0157:H7 and Yersinia enterocolitica. Other diseases of public health concern being investigated are swine influenza virus (SIV), giardiasis and toxoplasmosis.

Production issues, reproductive and grow-finish performance, and the prevalence of swine respiratory diseases and porcine proliferative enteritis (ileitis) are also being studied.

Overall, the study found the prevalence of swine pathogens to be surprisingly high. The researchers theorized that this was due to the pathogens' subclinical nature and the difficulty in identifying them. Development of rapid and sensitive tests is resolving those concerns.

For instance, antibodies to SIV (H 1 N 1 subtype), thought to be of limited prevalence, have been detected on 80% of Ontario farms, including high-health herds using strict biosecurity procedures.

Researchers looked at Toxoplasma gondii, a parasite found in pigs that can cause toxoplasmosis in humans and encephalitis in immune-compromised patients. The main source of pig infection is from exposure to cats. About one-third of participants in the study allowed cats into the pig barn. At least one positive finishing hog was identified on six of 84 farms tested, with 1% of all sera testing positive. All positive farms had cats in the barn.

Levels of other parasites, possibly significant to humans, included: Giardia lamblia, 25%; Cryptosporidium spp., 5%; and Balantidium coli, 76%. Results were based on fecal samples.

The survey revealed that 40% of gilts were negative for parvovirus, which was higher than expected and left them at risk for infection at breeding. Ileitis was detected in most herds, with a prevalence of 70-90%, depending on which serological test was used.

One disease organism not previously found in North American swine was *E.* coli 0157:H7. The pathogen, commonly found in cattle, is responsible for the so-called "hamburger disease." Three farms out of 44 tested positive for low levels of the Shiga toxin-producing *E.* coli. So far there has been no link established between infected pigs and human disease.

This study is considered the first step in reducing or eradicating swine diseases of public health and economic significance.

Researcher: Robert Friendship, DVM, University of Guelph. Phone (519) 824-4120, ext. 4022; fax (519) 763-3117 or e-mail rfriends@ovc.uoguelph.ca.

New test finds some on-farm E. coli

BY JIM ROMAHN, *Ontario Farmer staff,* 18 mars 2003
http://res2.agr.ca/initiatives/manurenet/archive/of030318.pdf

Guelph - A survey of 44 hog herds has turned up E. coli 0157:H7 in four of them. This contrasts with a 1995 U.S. survey, which reported none of this strain of harmful bacteria on hog farms. A team from the University of Guelph, led by Dr. Carlton Gyles, decided to take a closer look using a more sensitive test, mainly because researchers in Chile, Japan, the Netherlands and Norway, did find E. coli 0157:H7 in pigs. This is the bacterial strain that affected about 7,000 people who drank Walkerton water.

The Guelph team collected manure samples from 15 grower or finisher pigs on each of the 44 farms. On one farm, 12 of the 15 were carrying the toxin-producing strain of E. coli 0157:H7. One of the four farms had the same number strain, but it did not produce toxins. On one farm, seven of the 15 sampled pigs had the toxin-producing strain and the last of the three had only one of the 15 sampled pigs shedding the toxin-producing strain of E. coli 0157:H7.

At the least, the finding should alert hog farmers to take extra care in spreading manure so it doesn't contaminate drinking water. The study team says pork itself presents relatively little risk to consumers because this strain of bacteria is readily killed by normal cooking.

Dr. R.M. Friendship led another team that found that "pigs are the primary reservoir of human pathogenic Yersinia enterocolitica" bacteria. This bacteria most commonly sickens young children and they develop a fever, bloody diarrhea and abdominal pain. The U.S. estimates it has 96,000 cases a year of this form of bacteria poisoning and 1,200 of the victims require hospitalization. Ninety per cent of these cases develop from food. Refrigeration is not a good defence, says a report of all research findings provided to Ontario hog producers, because this bacteria "will grow at refrigerator temperature." In a survey of 77 finishing barns last summer, the study team found this bacteria on 19 farms, which is 24.6 per cent. Between four and 26 per cent of the pigs were infected in barns where the bacteria was identified.

The incidence in this survey was much lower than in previous survey reports of 68 per cent of barns in Ontario, 80 per cent in Quebec and 36 per cent in Finland. There is another report from Dr. Friendship in the 52-page research report that indicates there is an increasing rate of K88 and E. coli bacteria that are resistant to antibiotics. These bacteria can cause diarrhea in weaned pigs.

The team found that mortality rates doubled to five per cent at farms where K88 and E. coli were identified. They found resistance rates of 48 per cent to Neomycin, 15 per cent to Ampramycin and Trimehtoprin-sulfa, 89 per cent to Tetracycline and 25 per cent to Ampicillin.

Friendship headed another team that found three common intestinal parasites on hog farms - Giardia duodenalis, Cryptosporidium spp and Balantidium coli. All three can infect people. None of the farms that dewormed pigs with fenbendazole had these parasites. However, of the 77 farms surveyed, 15 had Giardia, five had Cryptosporidium and 58 had Balantidium. Three farms had all three parasites. There have been a number of reports of human infections from drinking water polluted with farm manure. Kitchener's drinking water was polluted by spring runoff one year in the early 1980s.

An animal behaviour report from S. Torrey and T.M. Widowski indicates weaned piglets fare better if drinking water is offered in bowls instead of via nipples. They spent "significantly less time belly nosing and nosing/chewing than piglets with a bite nipple drinker and they drank less water, ate more feed during the first two days after weaning." In a second report, they say "piglets that belly-nose will have slower growth rates post weaning.

Finding the bacterial needle in the haystack

by KEN BENNETT, *BETTER FARMING,* April 2002
http://res2.agr.ca/initiatives/manurenet/archive/bf_apr_2002.pdf

For the first time in North America, scientists have identified the deadly E. coli 0157-H7 strain in hog manure thanks to new and ultra-sensitive testing methods

Dr. Carlton Gyles, a professor of pathobiology at the University of Guelph, is in charge of the key bacteriology testing for the Swine Sentinel Herd project, a health monitoring program. "We are looking for three bacterium, specifically salmonella, Escherichia coli 0157 and Yersinia enterocolitica," he says. Perhaps the most renowned of these is the deadly strain E. coli 0157-H7, which recently made the news in Walkerton. In a key finding, his study showed that the bacterium previously thought to grow only in cattle gut was also found in hogs.

However, Gyles, an international expert on E. coli, is quick to point out that the sensitivity of the 0157 test is what is new, probably not the fact that the strain exists in North American hogs. "I suspect that it's been around a long time," he says. "But now we have the methods to detect it in low numbers." In the study, Gyles reported that out of 100 herds, 44 were found to have the 0157 strain. While this may cause alarm bells to sound in many ears, Gyles says "there are lots of 0157s in pigs that are non-pathogenic for humans," he says. "We've known that for over 20 years. They've found 0157 in pigs, but they've never found 0157-H7." In order to be harmful to humans, he emphasizes it has to either be 0157H7 or 0157-H (negative) and must also produce toxin. "Of 44 herds in this study, only three had toxin producing 0157-H7." One other herd produced 0157-H7 but was not toxic.

While the strain has been measured in other parts of the world before, this is the first time anyone has isolated 0157H7 from pig manure in North America. Gyles describes the search for 0157-H7 as like looking for a needle in a haystack. Testing is immediately overwhelmed by massive amounts of other bacteria. Any particular sample contains about one billion E.coli of various kinds within a larger pool of different bacteria 100 times greater in number.

Where it is found, he says, 0157-H7 was in a ratio of one in a million to other E. coli, or an estimated 1,000 organisms per gram of sample. While this is considered a relatively low number, for a coliform that has been reported to cause human infection with as few as 10 to 100 organisms, it is significant.

What diminishes the triumph of Gyles' achievement is that it is not welcome news to pork producers. Veterinary scientist Dr. Tim Blackwell believes the industry should check its response. "There's always the desire to close your eyes and hope it will go away. But the sign of a mature industry, of a really mature group of producers, is to say we want to know everything about our operation, good or bad, because we can't begin to fix it if we don't know it's there," he says.

Pigs linked to E. coli infection: Hog farms not immune to Walkerton strain, researchers find

Tom Spears - *The Ottawa Citizen* - Tuesday, November 26, 2002
http://www.creekwebsite.org/NewsItems/year2003/news03028.htm

Canadian scientists have discovered that hogs carry the same deadly strain of E. coli bacteria that killed and sickened people in Walkerton, disproving a theory that cattle spread the microbes but hogs were somehow immune. There are many types of E. coli, distinguished by different genes. The most dangerous by far, called O157:H7, entered the water supply of Walkerton in May 2000 after heavy rains washed contaminated manure from a dairy farm.

Since then, hog producers have fended off concerns about contamination from factory hog farms by claiming that hogs are totally free of this strain of E. coli. New hog farms, often with several thousand hogs in each barn, are springing up all across southern Ontario, as well as Quebec, Manitoba, New Brunswick and Saskatchewan.

But now research at the University of Guelph and Health Canada shows that hogs do carry the E. coli strain after all. It's not yet known how many hogs carry the strain of bacteria and "shed" them in manure.

The discovery "is very recent," said Carlton Gyles, a professor of microbiology at Guelph, which is Canada's biggest agricultural school. In June he announced his work to a conference of the International Pig Veterinary Society in Ames, Iowa, and also presented results at a meeting in Centralia, Ont., north of London.

"For a long time we believed that they did not (spread O157:H7) because there have not been a lot of studies looking at it," Mr. Gyles said. One large study in the mid-1990s, where U.S. Department of Agriculture scientists looked at 4,000 hog manure samples, appeared to show none of them had the dangerous E. coli strain. But that study did not use the most sensitive techniques.

"We used the best current techniques and we could find them (E. coli bacteria)," Mr. Gyles said. They are in lower concentrations in hogs than in cattle, he said. As well, it's not yet known how many hogs are infected.

But at the same time, he said even even a low concentration may turn out to be dangerous if it is found in millions of litres of liquid manure, which giant hog farms often store in vats and spray on farm fields all at once. "They tend to be in low numbers, but we certainly found them... If they are excreting the organism they certainly could contaminate the environment."

E. coli infection often causes severe bloody diarrhea and abdominal cramps, and can cause kidney failure and death.

In Sarsfield, where a Quebec company plans to convert a dairy farm to intensive hog production, one pig farm opponent says the discovery "will have major implications because of Walkerton." "We're trying to get all that type of information together," said Cumberland councillor Phil McNeely. "It's certainly something that should create concern."

He said the presence of E. coli in pig manure should be considered as the province draws up its new regulations on manure management, to be issued next spring.

In Guelph, Mr. Gyles's work is not over. He's trying to pin down the numbers, and also to learn more characteristics of the bacteria. The remaining mystery is that even O157:H7 has two different sub-types, or "lineages." One is found in humans and cattle, the other in cattle but not in humans. "We don't know whether a pig will carry strains of human lineage or bovine (cattle) lineage." Mr. Gyles said. "We believe -- we don't know for sure -- that it's only the human one that makes you sick. But clearly cattle carry human-type strains as well." Genetic researchers in Nebraska and at Health Canada are currently working to interpret the entire genome, or full set of 4,000 genes, in O157:H7. So far pigs have never been shown to cause E. coli poisoning in humans, he said, "perhaps because pork tends to be cooked thoroughly.

He's currently trying to find out how many hogs carry the bacterium, and how many bacteria a single pig will carry and excrete.

"We still don't have a good handle on the level of the risk, basically."

In cattle, infection comes and goes unpredictably, like a cold bug spreading in an office. "You test a herd this week and you get one cow positive. You test next week and that cow will be negative and maybe another one will be positive," he said. "We believe what is happening is they become infected, they contaminate the environment and they become reinfected."

Nutrient legislation omits threat of pathogens to groundwater

A U. of G. researcher says pathogens travel more readily through clay soils than nitrogen

BY JIM ROMAHN, *Ontario Farmer staff*, March 18, 2003.
http://res2.agr.ca/initiatives/manurenet/archive/of030318.pdf

Guelph - There is no mention of pathogens in the nutrient management regulations. Gordon Coukell, chairman of Dairy Farmers of Ontario and a leading member of the Ontario Farm Environmental Coalition, says he assumes that when farmers tackle the two named issues - nitrogen and phosphorous - in the nutrient management program, they will also reduce pathogens reaching water.

That's not necessarily so, says Dr. Michael Goss of the University of Guelph. He started researching nutrients, especially nitrogen, and has more recently been concentrating on pathogens, and said sometimes nitrogen and pathogen flows to drinking water are at odds.

For example, nitrogen tends to leach more through coarse-textured soils, such as sand and gravel, to groundwater, he said. But pathogens - mainly diseasecausing bacteria - do not travel readily through these same soils to groundwater. On the other hand, pathogens do seem to travel more readily through fine-textured (eg. clay) soils to groundwater, but nitrogen does not. Coukell shared another assumption that harmful bacteria are less likely to pose a threat during cool weather, which is characteristic of the more popular times for spreading manure in the spring or fall.

Goss said the reverse seems to be at play because the warmth of near-surface soils can be enough to kill harmful bacteria. Composted manure should also reach temperatures high enough to kill harmful bacteria; indeed, it's often high enough to kill weed seeds. Goss noted that widespread well water surveys taken in the 1950s and 1990s indicate little change in the incidence of harmfully-high levels of nitrates, but there was a doubling in the incidence of harmful bacteria.

Goss said he speculated then - and still believes now - that the difference is the introduction of liquid manure systems. Straw that soaks up urine and ties up nitrogen keeps them from leaching through coarse-textured soils into groundwater, or running off the surface into streams and rivers. Liquid manure is also more likely to run down worm holes, pores and soil cracks.

Goss would like to increase his research in this and other areas related to nutrient management, but said there has been no increase in federal or provincial government funding for this research. Both the federal and provincial agriculture departments have been devoting an increasing percentage of their research budgets to projects partially funded from the private sector. There is little private-sector interest in research related to nutrient management because there's not much that could be brought to market as a product or service that could be sold for a profit. There has been no indication that the Ontario Ministry of the Environment intends to gather baseline data on pathogen loads in surface or groundwater, or has a comprehensive program to track trends in pathogen incidence and/or levels in water.