REVIEW ARTICLE

Q Fever: An Emerging Public Health Concern in Canada

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ABSTRACT

Q fever in humans and coxiellosis in livestock are on the increase in Canada. The progressive spread of *Coxiella burnetii* takes place in the animal reservoirs of the rickettsia, mainly domestic ruminants. Human Q fever is a reverberation of the coxiellosis situation on our farms. Increasing animal concentration resulting from the industrialization of agriculture and oversight of the infection in livestock permitted the extension of the zoonotic problem on the farms. Initiative for control of coxiellosis, however, is called for by public health interests at the present time to assure occupational health and safety for workers, and the protection of the general population residing in coxiella threatened environments.

RÉSUMÉ

La fièvre Q humaine et la coxiellose du cheptel s'étendent, au Canada. La diffusion progressive de *Coxiella burnetii* s'opère à l'intérieur du reservoir animal de la rickettsie, dont les hôtes principaux sont les ruminants domestiques; la fièvre Q humaine n'est qu'un reflet de la situation epidémiologique dans les fermes. L'accroissement de la concentration des animaux, due à l'industrialisation agricole, et le manque d'attention à l'infection par *Coxiella* ont permis le développement du problème zoonotique, dans les fermes. Les responsables de la santé publique doivent prendre l'initiative pour contrôler le problème, afin d'assurer la sécurité, au lieu de travail, et la protection de la population qui vit dans les milieux menacés par cette rickettsie.

INTRODUCTION

Coxiella burnetii has been known to occur in Canada since 1952 (1); it causes Q fever in humans and a mostly asymptomatic infection in livestock, especially domestic ruminants. Although a zoonotic disease, it is not controlled in Canada by public health or animal health regulations. For decades it was considered a minor problem by the health services, but has been mentioned in recent years in the medical literature with increasing frequency and from areas where the disease was unknown. A general review on Q fever in Canadian livestock was published by McKiel in 1964 (2), a synopsis of which is given in Table I. An update on human and animal coxiellosis in Canada is presented in this paper, and better surveillance of the spread of the infection in the human and farm animal species and appropriate control measures are recommended.

HUMAN Q FEVER IN CANADA

The occurrence of human Q fever was first reported from Quebec in 1952 by Pavilanis (1) whose group conducted a serosurvey in human subjects and found significant titers of antibodies against *C. burnetii* in 4.8% of sera. The first clinical case in the province was diagnosed by Marc-Aurèle and coworkers in 1956 in a farmer (3). An industrial Q fever epidemic occurred in the same year at the slaughterhouse in Princeville, 30 miles south of the St. Lawrence River, 60 miles from Quebec City (4). Between April 2 and 19, 62 employees, 36.5% of the personnel, contracted Q fever from animals processed at the Co-operative Abattoir of Princeville. The same report (4) also mentioned a personal communication from P. Fiset to one of the authors, stating "To date we have tested over 2000 samples of serum and we find a much higher percentage of positive serums in the East (about 5% for Quebec, New Brunswick and Nova Scotia) than in the West (about 1% for Manitoba and Alberta)". One Quebec case in Richmond County in the Eastern Townships in 1960 was reported by McKiel (2). Another was described in 1966 by Somlo and Kovalik (5) which was associated with acute thyroiditis.

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TABLE I. Coxiellosis in Canadian Cattle 1959/62[a]

Province	No. of Herds Tested	No. positive	% positive
British Columbia	2595	59	2.3
Alberta	1022	60	6.8
Saskatchewan	771	8	1.0
Manitoba	5540	3	0.1
Ontario	4567	103	2.3
Quebec	1599	633	39.6
Nova Scotia	576	0	0
New Brunswick	693	0	0
Prince Edward Island	209	0	0
Newfoundland	80	1	1.3

[a]Data from McKiel (2)

In 1983, J.P. Breton, of the Division of Infectious Diseases, Quebec Department of Social Affairs, cited in a communication in the Canada Diseases Weekly Report (6) three cases resulting from contact with goats in 1975 and 13 cases of Q fever during the five-month period April-August 1982. Twelve males and one female, from 31 to 53 years of age, residing in Montreal (six cases), south of Montreal (five cases), in Laval (one case) and Rouyn-Noranda (one case) were affected, 11 with liver involvement. In six cases the source of infection was unknown, two persons had contact with goats and sheep, three had visited farms or agricultural exhibits and one patient had eaten goat cheese.

The Ontario experience with Q fever dates from May 1960. The disease appeared in two infants living in a rural district 30 miles northwest of Toronto. Contact with sheep was thought to be the source of infection (7). In 1960 Fish and Labszoffsky (8) observed that despite proven coxiella infection of dairy cattle in southwestern Ontario, no history or illness suggestive of Q fever could be elicited amongst dairy farmer or their families, and Q fever antibodies had not been detected in the sera of several thousand residents of Ontario during the preceding ten years. Velland (9,10) noted in 1980 that a total of nine cases of Q fever had been reported for the whole of Canada from 1960 to 1980, but that no case was reported during the years 1976 to 1980. This apparently negative period ended in the early 80's with a Q fever outbreak at a Toronto hospital where pregnant sheep were used for experimental studies. Blood tests revealed that 59 persons had contracted the infection, 12 persons were sick and two had to be hospitalized. A comparative survey of blood donors from the Toronto urban area showed seropositivity in the general population of only 0.6% (11). The new awareness of the occurrence of *C. burnetii* in Ontario stimulated more active diagnositic efforts by physicians, and for the last three years 30 to 45 Q fever cases, mostly isolated ones, have been reported to the Ontario Ministry of Health (12).

In Alberta, Q fever was diagnosed first in 1963 in an infant on an Indian reservation 40 miles west of Edmonton. A survey among 44 band members detected two other infected persons (13). In 1976 the Foothills Hospital in Calgary started serotesting for coxiella antibodies all patients with undetermined pyrexia, respiratory, hepatic and cardiac illnesses. As of January 1982 eight patients reacted in the complement-fixation (CF) test at 1:16 or higher titers. Seven patients were males, six had contact with ungulates and one patient suffered from chronic coxiellosis (14).

The Atlantic Provinces are practically *terra nova* for Q fever on both the human and animal levels. Human Q fever was entirely ignored there until 1979 when a study on the causes of atypical pneumonia showed that of 27 patients three had Q fever (15), and every year since then, cases have occurred. A peak was reached in 1985 when 57 cases were diagnosed. Between 1979 and 1987 170 cases occurred, 115 were males and 55 females. The mean age was 39.6 ± 16.4 years with a range from 12 to 89 years. Atypical pneumonia required hospitalization of 148 (82%) patients. A special feature to the epidemiology of Q fever in Nova Scotia is the association with infected parturient cats; from 1979 to 1987 24 separate cat-related incidents of Q fever were observed in the province (16,17). Physicians at Dalhousie University and the Victoria General Hospital in Halifax reported also endocarditis due to Q fever (19), a condition described occasionally in Europe and Australia (19,20) but said to be rare in North America (21,22). The Dalhousie team surveyed veterinarians and slaughterhouse workers in the province with the finding that 49% of veterinarians and 35% of meat workers had antibodies to *C. burnetii*. Definite infection hazard was associated with exposure to sheep placentas, and slaughtering cattle was a significant risk factor for positive antibody titers in slaughterhouse workers. Neither veterinarians nor meat workers suffering from symptomatic Q fever were known during a five year span in the late 70's and early 80's (23). A survey of the general population by indirect microimmunofluorescence using phase II antigen A revealed a reactor rate of 11.8% among 997 blood donors from 16 counties (24).

No information was found on human Q fever in British Columbia, Saskatchewan and Manitoba.

COXIELLOSIS IN CANADIAN CATTLE

Since human Q fever has its origin in the animal reservoirs of *C. burnetii*, the apparent rise of its prevalence in humans should have been reflected in an extension of the infection in the animal hosts. As an asymptomatic infection without economic repercussion, livestock coxiellosis was of only marginal interest to animal health services, and few data are available on its occurrence. The scarcity of data is also a reflection of past technical difficulties: the CF test, the classical mainstay of serodiagnosis in human Q fever, has notable shortcomings with sera from several animal species, in particular from cattle (25). The capillary agglutination (CA) test of Luoto (26) has been used instead, with either blood serum or milk, to detect coxiellosis in animals. Recently introduced enzyme-linked immunosorbent assay (ELISA) methods have overcome these serodiagnostic obstacles (27,28).

Initial surveys on bovine coxiellosis were carried out in British Columbia in 1954-57. Guinea pigs were injected with raw milk, and were later checked for seroconversion by CF. A first series on 56 herds in the Fraser Valley, on 30 herds from Vancouver Island, and 122 herds kept close to the Canada-US border yielded negative results (29,30). A second series of 1959-60 using the CA test with bovine serum found a herd reactor rate of 59/2595 (2.3%), mostly in the Fraser and Okanagan valleys (31).

Milk testing of Alberta dairy cattle by CA in 1959-64 showed spread of coxiellosis with herd reactor rates increasing from 0.8% to 7.7%. Higher regional prevalences were found in the Lethbridge-Medicine Hat (34.9%) and Calgary (13.6%) areas, while further north in the Edmonton area it was only 3.8% (2,13). A few sheep, elk and buffaloes examined were seronegative (13).

The provinces of Saskatchewan and Manitoba reported low herd reactor rates of 1% and 0.1% respectively (2,32).

A sharp increase in the prevalence of coxiellosis was noted in Ontario dairy cattle herds between 1964 and 1984. The 1964 survey indicated a rather low herd prevalence rate of only 2.3% for dairy cattle (2). Another independent survey in 1960 among dairy herds in the counties of Waterloo, Brant, Wentworth, and Haldimand found 14 of 200 tested herds (7%) positive by CA tests (8). In contract to this, a 1984/85 survey by ELISA (33) of dairy herds revealed coxiella infection in 67% of all herds tested. Comparative regional listings given in Table II show clearly increases during the two decades from 1964 to 1984 in the province, with 75% or higher herd reactor rates everywhere, except in eastern Ontario towards the Quebec border where only 33% of herds reacted.

Quebec had the highest bovine coxiellosis rate in Canada in 1964 with 39.6% of positive dairy herds province-wide. Individual counties varied from 70% (Missiquoi) to 22.2% (Brome) herd infection rates (2).

The Maritime Provinces were found in 1960-61 to be free of bovine coxiellosis except one herd in Newfoundland which gave this province a herd infection rate of 1.3% (2). Newer data provided by Marrie *et al* (24) in Nova Scotia with the use of an indirect microimmunofluorescence test revealed antibodies to phase II *C. burnetii* in 23.8% of 214 cattle and 24.2% of these reacted with phase I antigens.

TABLE II. Spread of Coxiellosis in Ontario Dairy Herds

Region	1964[a] No. Herds Pos./No. Tested (% pos.)	1984[b] No. Herds Pos./No. Tested (% pos.)
Southwestern Ontario	23/1879 (1.2%)	86/110 (78%)
Central Ontario	53/ 521 (10.2%)	18/ 22 (82%)
Eastern Ontario	0/ 843 (0%)	17/ 51 (33%)
Northern Ontario	27/1324 (2.0%)	12/ 16 (75%)

[a]Data from McKiel (2)
[b]Data from Lang (33)

COXIELLOSIS IN SMALL RUMINANTS

Although sheep and goat operations occupy only a minor segment of farm activities in Canada, it is believed that these two species account for most human Q fever cases, especially on the epidemic scale (12).

According to official estimates, the national flock of 748 000 sheep was distributed in 13 000 farms throughout Canada. Sheep producers are about equally distributed among hobby farmers, small flock owners, and large producers. One third of sheep producers have been in the industry for less than five years. There is a considerable turnover of farmers entering and leaving the sheep industry (Real Bouchard, Animal Production, Agriculture Canada at Workshop on Sheep Research, Ottawa, December 22, 1986), a particularly aggravating aspect in the epidemiology of human Q fever, since it increases the contact of susceptible people with coxiella-carrying animals.

In Ontario about 320 000 sheep are kept throughout the province; 609 flocks were registered in 1985 with the Record of Performance program of the Ontario Ministry of Agriculture and Food. Of these 609, 45% were small flocks with fewer than 50 animals, while 1.5% counted more than 500 head. The existence of coxiellosis in Ontario sheep is known from human Q fever cases attributed to this species, especially the 1982 outbreak at a Toronto hospital where pregnant ewes were used for experimental investigations; of 37 sheep 34 (92%) were found to be seropositive (10). Limited random testing by ELISA for coxiella antibodies in sheep (550 sera from ten flocks from Ontario and four from Alberta) indicated seroreactivity in three herds in the Ontario sheep and none for Alberta sheep; in none of the flocks was abortion mentioned as a problem (G. Lang, unpublished data). In Nova Scotia, Marrie *et al* (24) found antibodies to *C. burnetii* phase II antigen in only 6.7% of 329 sheep, and in none of these to phase I antigen.

The goat population in Canada is small but increasing; in Ontario about 70 goat herds supply milk to dairies specializing in goat milk and cheese distribution to commercial outlets. A few dairy goat herds include over 300 milking goats. A survey using ELISA in 20 Ontario goat herds (426 animals) revealed a coxiella seroreactivity in four herds, three of which were over 50%. This gives a coxiella herd prevalence in goats of 20% in Ontario (34). The survey in Nova Scotia examined 29 goats of which 7% and 3.5% had antibodies to phase II and phase I antigens respectively (24). Data on ovine and caprine coxiellosis elsewhere in Canada are not available.

THE EPIDEMIOLOGICAL PERSPECTIVE

Coxiellosis is an underrated and widely neglected public health problem in North America. In Canada as well as in California (35) and elsewhere many more human cases of Q fever occur each year than of brucellosis, a zoonosis which causes great concern to human and animal health officials. The reported human Q fever morbidity was 30 to 45 cases per year for the past three years in Ontario (12) in a population of nine million, while 16 clinical cases per year are registered among the 35 million Californians (36), and 80 to 100 cases annually in

Great Britain with a population of 50 million (37). Q fever is both endemic (9,12) and enzootic (23,24,33) in Canada; the official opinion, however, on the Q fever status of Canada, given by government services to the World Health Organization and the Food and Agriculture Organization in 1986 (38) is "low sporadic occurrence", erroneous information which is presumably based largely on a survey published in 1965 (2).

Is the increase in Q fever morbidity indicative of a real progressive zoonosis, or simply the apparent reflection of improved diagnostic efforts? An example of the latter instance was recently described for the Netherlands, which like Canada, were previously believed to have few problems with *C. burnetii*. A seroepidemiological study in the Dutch population for antibodies to *C. burnetii* by the indirect immunofluorescence test (39) revealed no differences in reactor rates in 1968 and 1983, indicating that, contrary to earlier assumptions, Q fever has been endemic in the Netherlands for a long time. An appraisal of Canadian serological data is difficult. Available data obtained by the CF test are unreliable, since these are precisely the data on which the official, but nevertheless erroneous assumptions of low occurrence of Q fever in both Canada and the Netherlands were based. Valid comparisons, since based on immunofluorescence tests, can be made with the data recently published by Marrie and coworkers in Nova Scotia (15,16,22,23) and the Dutch findings: in the Netherlands 83.7% of veterinarians, 68% of residents of dairy farms and 31.3% of blood donors from Rotterdam reacted positively in the test. In Nova Scotia the reactor rate in veterinarians was 49%, in meat workers 35% and 11.8% among blood donors from 16 counties (23). While the reactor rates in Canada were somewhat lower than the Dutch ones, it should not be overlooked that the population densities and risk of exposure in the two countries are not comparable. Difficult to reconcile are the statements that, on the one hand Q fever is endemic in Ontario, yet on the other hand the general population is still largely seronegative (0.6% in blood donors from Toronto) thus highly susceptible to *C. burnetii* (9,11,12). The endemicity of Q fever is clearer in the Atlantic Provinces where microimmunofluorescence revealed 11.8% rectors in Nova Scotia blood donors and 14.6% in Prince Edward Island (18). One plausible explanation for the Ontario situation would be that the endemicity is of recent date consecutive to the enzootic establishment of *C. burnetii* in livestock of longer standing; the serosurvey in dairy cattle supports this view, but only epidemiological data from systematic surveys of the human urban and rural populations can cast light on the relationship of the zoonotic organism and humans in Ontario.

What is the importance of the various animal species in maintaining coxiellosis in an area? Sheep and goats are often found to be the culprits in transmitting Q fever to humans, but small domestic ruminants do not seem to be the principal, perpetuating hosts of *C. burnetii*; reactor rates indicate that cattle, particularly dairy cows appear to assure the large-scale survival of coxiellas, and to be amplifying hosts in the epidemiological context of this zoonosis, at least in Ontario and the Atlantic Provinces (23). In Ontario the approximately 10 500 dairy herds, 1000 sheep flocks and 500 goat herds are actual and potential polluters of the environment with *C. burnetii*; they are distributed throughout the province, and dairy cows in particular are usually concentrated in proximity to dense human population centers. Livestock transport through cities and towns has been mentioned as a plausible source of human Q fever not traceable to direct animal contact (40).

There is reason to assume that coxiellosis is found in North America wherever livestock are raised. Unfortunately, the early warning of Luoto in 1960 (41) that coxiellosis was spreading in the dairy herds of the United States was ignored; in Illinois, Q fever was even removed from the list of reportable diseases (42). Control depends on precise knowledge of the location and extent of the infection, information generally not available either to public health or animal health authorities in relation to coxiellosis and Q fever. The absence of morbidity figures for Q fever in population centers with important cattle concentrations, as for instance British Columbia where the herd infection rate in 1960 was the same as in Ontario, is more plausibly explained by lack of diagnostic precision than by assuming a resistance of the population to coxiella infection or a lower prevalence of coxiellosis in cattle; more testing for Q fever in the etiological diagnosis of appropriate clinical syndromes is advisable throughout the continent. Also, a permanent surveillance program of livestock is indicated to monitor the progression or regression of the herd infection rates so that practical control strategies can be planned.

Q fever is an occupational health hazard. The occupations at risk include farm workers, veterinarians and their assistants, livestock dealers, transporters, auctioneers, dairy workers, bulk milk transporters and testers, slaughterhouse personnel, meat inspectors, hide and wool dealers and processors, faculty, staff and students at veterinary colleges and other teaching and research institutions where ruminants are handled.

Employees at risk in industrial plants and farms come under the "Safety at the Workingplace" regulations of the government agencies dealing with labor relations, and when infected by *C. burnetii* in the course of their work they should benefit from Workers' Compensation. This requires adequate information on the risk and appropriate medical supervision of the employees. The officials mandated to safeguard public health have to assure the safety of visitors to livestock auctions and exhibitions, to pet farms and even shopping malls that in spring display goat kids, lambs and calves in open pens. In these instances proof should be demanded that the animals originate from coxiella-free surroundings, or their access to public places should not be allowed. Owners of coxiella-free livestock require advice on how to maintain their stock free of infection, and should expect such advice from animal health officials, while farmers with seroreacting stock need advice on sanitation of their premises. The situation in the 1980's differs from that of the 1960's in that the ELISA (43-45) and immunofluorescence tests for coxiella antibodies are far superior in reliability and sensitivity to the traditional CF and microagglutination tests for differentiating infected

from uninfected livestock and make control and sanitation programs possible.

Who holds the mandate to protect the public from Q fever? Q fever is above all a public health problem and of less direct concern to the livestock industry or animal health authorities. Yet the control has to begin with the animal reservoirs of *C. burnetii*; animal owners and animal health officials tend to minimize the Q fever problem and perceive the control of coxiellosis as an undue burden (46). The farmer's part begins with proper care and hygiene of the parturient animal (disinfectable birthing stalls, safe disposal of afterbirth, disinfection of contaminated clothing and utensils) to reduce the microbial pollution of the environment. Veterinary services have to provide advice and diagnostic backup. Such measures do not require heavily subsidized eradication campaigns, but strong motivation. The motivation can be created by appropriate public health and animal health regulations, such as restriction of movement of infected animals, especially exclusion from public sales and exhibitions, surcharges for handling contaminated stock or products to cover costs for protective clothing and masks of exposed personnel, certification of coxiella-free herds and similar psychological persuasion. Seroepidemiological surveys for antibodies to *C. burnetii* can be added to existing survey schemes, and reportability of human and animal coxiellosis can be made obligatory to maintain better surveillance of the spread of the infection in the future.

Guidelines for the protection of personnel in research institutions handling pregnant sheep have been recently published (47); similar directives should be issued for establishments equally exposed to the risk of human Q fever. The precedence of public health authority over animal health services in matters of zoonoses was established in the recently revised Ontario regulations governing the handling of chlamydia-infected birds and poultry (48), which vest medical officers of health with the responsibility and jurisdiction for control and sanitation of birds and premises; a similar arrangement may be necessary in regard to the prevention of Q fever.

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