



The eradication of glanders in Canada

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Introduction

Glanders is primarily a disease of Equidae, but it can be transmitted to humans in contact with infected horses, and to carnivores through eating infected meat. The respiratory form of the disease in the horse is characterized by nasal discharge, ulceration of the mucosa of the respiratory tract, and suppurative pneumonia, while in the skin form, known as farcy, there are nodules, pustules, and ulcers on the skin. Glanders is an ancient disease, first described by the early Greek and Roman writers, such as Aristotle, Apsyrus, and Vegetius (1). The contagious nature of the disease was recognized by Sollysel in France in 1664; by the early 19th century, the transmission of glanders from horses to humans was well established in Europe (2), where the disease had been prevalent for several centuries, particularly among army horses.

The causative agent of glanders, *Pseudomonas mallei*, was isolated first by Loeffler and Schutz in Germany in 1882 and then by the French microbiologists Bouchard, Charrin, and Capitan in the same year (1). Of great importance in the control of glanders was the development of a specific diagnostic test in 1890. Working independently, Helman in St. Petersburg, Kalning in Dorpat, and Pearson in Philadelphia prepared mallein from cultures of *P. mallei*. Analogous to tuberculin, mallein elicited a delayed hypersensitivity reaction when injected subcutaneously or intradermally in infected horses.

The introduction of glanders into North America has not been precisely documented, but it is reasonable to assume that some of the horses imported from Europe by the early settlers were carriers of the infection. While the early American literature on farriery in the late 18th and early 19th centuries contains numerous descriptions of glanders (3), these publications were mainly reprints of texts originally published in England, and they fail to provide irrefutable evidence of the existence of the disease in North America at that time. However, it is clear that by the 2nd half of the 19th century, glanders was widespread in the United States, largely as a result of the American Civil War between 1861 and 1865. The extensive movement of horses during and after the war led to a major epidemic of the disease in the eastern United States (4), but there does not appear to have been major spread into Canada, where the disease was less prevalent.

Glanders is included among the List B diseases by the Office International des Épizooties. These comprise

transmissible diseases that are of socioeconomic or public health importance. Since *P. mallei* is an obligate parasite with a restricted host range (5), and since tests are available to detect carriers of the infection, there has been considerable success in the global eradication of glanders, which is now a rare disease. Of the 155 countries that reported to the Office International des Épizooties in 1999, glanders was present only in Brazil, Pakistan, and Mongolia (6). It was eradicated in western Europe by 1965, but cases were reported in eastern Europe as recently as 1998, and in North Africa in 1996. Glanders was eradicated in Great Britain in 1928, in the United States in 1934 (7), and in Canada in 1938. Canada was among the first countries to mount an organized eradication campaign, and the purpose of this paper is to trace the progress of the eradication of glanders in Canada from the tentative control measures that were instituted in the late 19th century to the successful federal campaign of the 20th century.

Control in the 19th century

Glanders was less prevalent in Canada than in the United States during the latter half of the 19th century. Although there was a significant outbreak of glanders in Montreal, including at least 3 human cases in 1885 (8), the incidence of the disease in the older provinces remained generally low, but it was much higher in Manitoba and the Northwest Territories, where almost 200 cases were reported in 1897 (9). This higher incidence was probably associated with the importation of infected horses from the United States to supply the needs of new settlers in this region.

Horses were not included in the federal *Animal Contagious Diseases Act* of 1879, so the control of glanders was a provincial responsibility, although, in 1883, Andrew Smith recommended inclusion of the disease in the federal legislation (10). The provincial control measures were not rigorous, except in Manitoba, although the provincial legislation passed in Ontario in 1884 was believed to have had a salutary effect (11). However, horses were still excluded from the *Animal Contagious Diseases Act* of 1885 and, in the same year, Duncan McEachran, who had been appointed chief veterinary inspector in the federal Department of Agriculture in 1881, echoed Smith's plea for the inclusion of horses in the legislation (8). At the same time, McEachran suggested that, with appropriate measures, glanders could be stamped out in a short time and at small cost. This theme was repeated by McEachran in his reports of 1892 (12) and 1893 (13). In the latter report, McEachran referred for the first time to the use of mallein as a diagnostic aid. In his 1892 report, McEachran had

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Table 1. Data on the eradication of glanders, 1904–1938^a

| Year | Horses tested | Horses destroyed | Compensation (\$) | Imports tested |
|---------|---------------|------------------|-------------------|---------------------------|
| 1904–05 | 4899 | 2113 | 147 851 | 0 |
| 1905–06 | 3957 | 1387 | 108 045 | 0 |
| 1906–07 | 8687 | 1881 | 142 057 | 0 |
| 1907–08 | 11 428 | 1324 | 102 868 | 0 |
| 1908–09 | 20 401 | 981 | 73 386 | 12 175 (242) ^b |
| 1909–10 | 24 330 | 627 | 48 686 | 17 916 (228) |
| 1910–11 | 28 599 | 666 | 57 122 | 16 182 (279) |
| 1911–12 | 31 434 | 853 | 77 439 | 15 005 (288) |
| 1912–13 | 22 829 | 638 | 60 271 | 12 159 (145) |
| 1913–14 | 12 430 | 353 | 34 563 | 7887 (80) |
| 1914–15 | 8781 | 338 | 35 556 | 5339 (39) |
| 1915–16 | 7523 | 241 | 23 102 | 3434 (11) |
| 1916–17 | 8441 | 228 | 22 238 | 3673 (4) |
| 1917–18 | 8805 | 190 | 19 849 | 5297 (13) |
| 1918–19 | 6384 | 83 | 9506 | 4054 (4) |
| 1919–20 | 7330 | 56 | 6763 | 5034 |
| 1920–21 | 1323 | 59 | 6070 | 4020 (11) |
| 1921–22 | 4060 | 29 | 2596 | 2897 (7) |
| 1922–23 | 9415 | 247 | 23 558 | 2643 (11) |
| 1923–24 | 4376 | 24 | 2400 | 3156 (13) |
| 1924–25 | 7254 | 287 | 15 722 | 1838 (6) |
| 1925–26 | 3080 | 45 | 3255 | 1131 |
| 1926–27 | 3762 | 22 | 1852 | 1586 (4) |
| 1927–28 | 6366 | 1 | 100 | 2392 |
| 1928–29 | 4933 | 38 | 2278 | 2014 |
| 1929–30 | 3543 | 26 | 1791 | 991 |
| 1930–31 | 1497 | 12 | 708 | 575 |
| 1931–32 | 1172 | 1 | 50 | 330 |
| 1932–33 | 1220 | 1 | 40 | 292 |
| 1933–34 | 2463 | 233 | 18 305 | 290 |
| 1934–35 | 15 273 | 128 | 7864 | 287 |
| 1935–36 | 3241 | 0 | 0 | 248 |
| 1936–37 | 4229 | 2 | 70 | 280 |
| 1937–38 | 2653 | 8 | 316 | 338 |
| 1938–39 | 1222 | 0 | 0 | 407 |

^aData from the Annual Reports of the Veterinary Director General. Ottawa: Department of Agriculture, 1905–1939

^bFigures in parentheses indicate the number of horses that tested positive

suggested that there were currently less than 500 horses in Canada affected with glanders, and that the disease could be exterminated for about \$50 000. Subsequent experience in the following century indicated that this was overly optimistic, probably based on serious under-reporting of the disease before the enactment of legislation that required mandatory reporting. However, it was not until 1897 that horses were included in the *Animal Contagious Diseases Act* (14). This was one of the prerequisites for the subsequent eradication of the disease.

In the period up to 1897, the only direct contribution to the control of glanders by the federal Department of Agriculture was the inspection of imported horses at the border with the United States for evidence of the disease. The first report of this activity was by D.H. McFadden in 1886, when 1063 horses and mules were imported into Manitoba through the Emerson Quarantine Station (15). Two years later, the same inspector noted that glanders was extremely prevalent in Dakota and that vigilance was needed to prevent the introduction of the disease into Manitoba (16). However, before the availability of mallein to test quarantined horses, clinical inspection alone failed to detect carriers of the infection. Because of the suspicion that glanders might be imported into Great Britain from Canada, the inspection of exported horses for evidence of the disease was instituted in 1896 (17); 10 years earlier, McEachran had urged an

eradication program for glanders in order to protect the export trade when an embargo was placed on the importation of Canadian horses by the state of Vermont due to the prevalence of glanders in the province of Quebec (18).

Following the inclusion of horses in the *Animal Contagious Diseases Act* in 1897, the federal Department of Agriculture began to play an active role in the control of glanders in the Northwest Territories, where the veterinary surgeons of the Northwest Mounted Police were empowered to serve as inspectors under the *Act* (19). On the discovery of an outbreak of glanders, the inspectors were instructed to kill all diseased horses, to quarantine suspicious cases and test them with mallein, and to supervise the cleansing and disinfection of the premises, as well as the deep burial of the carcasses. At this time, glanders was prevalent only in the Northwest Territories and Manitoba, and, in the latter, its control remained a provincial responsibility. McEachran's final report as chief veterinary inspector (20) included a bulletin for horse owners on the symptoms, diagnosis, and control of glanders, including details of the mallein test. Between 1897 and 1901, 395 and 252 horses were destroyed in the Northwest Territories and Manitoba, respectively, but, in 1901, only 5 cases were reported elsewhere in Canada — 2 in Ontario and 3 in British Columbia.

Eradication in the 20th century

In 1902, John Rutherford succeeded McEachran as chief veterinary inspector; in 1904, he was appointed veterinary director general, at the head of the newly formed Health of Animals Branch of the Department of Agriculture. Early in the century, Rutherford was instrumental in establishing the policies and procedures that would lead to the eventual eradication of glanders. A serious outbreak of the disease in the Ottawa district in 1902, and a number of minor outbreaks elsewhere in Ontario, as well as in Quebec, British Columbia, and the Yukon territory, together with the continuing high incidence of glanders in Manitoba and the Northwest Territories (21), justified the actions that were taken. In 1903, the *Animal Contagious Diseases Act* was amended to authorize the destruction of horses affected with glanders, and regulations were established in 1904 and 1905 by Order in Council under the *Act* for the control and eradication of the disease (14). Between 1902 and 1904, clinical cases were slaughtered without compensation, while horses that reacted to mallein were quarantined and retested, and those that failed to react to subsequent tests were released from quarantine. However, by 1904, it was apparent that these ceased reactors remained capable of transmitting the disease to other horses, and the policy was changed to require all reactors to be slaughtered and their owners compensated. Further changes in March of the following year included the payment of compensation for animals that showed clinical signs, as well as the inclusion of Manitoba in the federal control program, so that, by 1905, the Health of Animals Branch was responsible for the control of glanders throughout Canada (22).

The policies were now in place that would lead to eventual eradication, and they were immediately effective in bringing the disease under control. In the 6-year period following the introduction of these changes, the number of horses slaughtered declined annually from 2113 to 666, and the amount of compensation paid declined from \$147 891 to \$57 122 (Table 1). Canada was a pioneer in the establishment of effective policies for the eradication of glanders. In Great Britain in 1905, the Board of Agriculture noted a steep rise in the incidence of glanders in that country (23) and urged the adoption of measures similar to those that were in place in Canada, although it was not until 1908 that the Board authorized the slaughter of all reactors to the mallein test. In the United States, the Canadian control measures were endorsed by a meeting of the American Veterinary Medical Association in 1906, and the meeting recommended that the American federal and state authorities adopt a similar approach, but little was done on a national scale to control or eradicate glanders until 1913 (7).

A further step was necessary to ensure the success of the eradication campaign. It was noted above that the clinical inspection of horses at the border with the United States failed to prevent the importation of carriers of the infection and, in 1907, stringent regulations were placed on equine imports. All horses had to be tested with mallein before they were allowed to enter Canada, although test certificates signed by United States federal

inspectors were acceptable. Horses without certificates were held at the border and tested by Canadian inspectors. In addition, the importation of unbroken range horses, which had previously been driven across the frontier in large numbers, was prohibited, since it was impossible to inspect them or to subject them to the mallein test (22).

Data on the progress of the eradication campaign are given in Table 1. During the first 10 years, the numbers of horses destroyed each year steadily declined, while the number of horses tested increased. The latter reflected the increasingly rigorous tracing and testing of contacts in each outbreak. In the first 2 decades of the century, the majority of cases occurred in Saskatchewan and Alberta, which were former components of the Northwest Territories. Thus, of the 666 horses slaughtered between April 1910 and March 1911, 552 were in Saskatchewan and 42 in Alberta (22). This reflected the extent to which the disease had become established in these provinces during the previous century, when the limited control measures enforced by the very small contingent of veterinary inspectors attached to the Northwest Mounted Police were relatively ineffective.

Manitoba fared better than Saskatchewan in the early years of the eradication campaign, probably because this province had a relatively effective program before the control of glanders became a federal responsibility. The field work in the federal program in Manitoba was under the direction of C.D. McGilvray, who gave a detailed report on the progress of eradication in that province (24). In his 1915 report, Fred Torrance, who had replaced Rutherford as chief veterinary officer in 1912, commented on the problems presented by the prairie provinces (25). He indicated that the influx of new settlers induced dealers to transport horses long distances by train under conditions highly favorable to the spread of infection. The dispersal of these horses disseminated the infection very widely, and the settlers often failed to notify the authorities of the existence of the disease, which could spread widely before appropriate measures were taken.

The mallein testing of imported horses began in 1908. Initially, very large numbers of horses were tested, and although significant numbers of animals were refused admission on the basis of this test (Table 1), there were problems of enforcement, particularly during the spring rush of immigration. Rutherford pointed out that, at this time, some horses were permitted to reach their destination points before being tested and that some new settlers would change their original destinations, so that it was difficult to trace the animals in order to test them (26). In 1922, Torrance expressed disappointment that glanders had yet to be eradicated, and he suggested that a single mallein test on imported animals did not provide an absolute guarantee of their freedom from infection, since they may have been recently infected and not yet reactive to mallein (27). Such animals could then spread the infection for some time before clinical cases were reported. Eradication of glanders in the United States in 1934 eliminated the risk of importing the infection, and this no doubt contributed to the eradication of glanders in Canada 4 years later.

Although Torrance was disappointed that eradication was not complete by 1922, much had been achieved, in that the 29 cases nationwide between April 1921 and March 1922 was the smallest number to be reported since the campaign began, although only the maritime provinces were free of infection (27). However, with only 4 cases in Manitoba, 4 in Saskatchewan, and 2 in Alberta, the incidence in the prairie provinces had been greatly reduced, but there were 17 cases in Quebec in the same year. Unfortunately, in the following year, when George Hilton replaced Torrance as veterinary director general, 4 outbreaks were dealt with in Manitoba, necessitating the slaughter of 116 horses; in Saskatchewan, 86 horses were slaughtered (28). These control measures appeared to be effective, since between April 1923 and March 1924, only 24 reactors were slaughtered, all in Quebec; but, in the following year, there were extensive outbreaks in Alberta and Saskatchewan, and a small outbreak in Quebec. A number of horses from the outbreak in Alberta had been shipped to British Columbia before the disease was reported, and it was necessary to slaughter a total of 287 animals (29).

The incidence of glanders was relatively high in 2 more years before eradication was achieved (Table 1). Between April 1933 and March 1934, a serious outbreak occurred in the Eastern Townships of Quebec, where 1167 horses were mallein tested and 233 were destroyed (30). This outbreak carried over into the following year, when an additional 8090 horses were tested in Quebec and 88 reactors were destroyed. In the same year, there was an outbreak of glanders in Alberta, involving the testing of 5266 horses and the destruction of 40 animals (31). In 1935, for the first time since the initiation of the glanders eradication campaign, no reactors were found. In 1936, what was to prove to be the last outbreak of glanders in Canada occurred in the Naicam district, northeast of Humboldt in Saskatchewan, where a clinical case was found and the contacts were mallein-tested. Two horses were slaughtered (32), and, in the following year, continued testing led to the slaughter of a further 8 horses, bringing the outbreak to an end (33). No further outbreaks of clinical glanders have been reported since 1938, although the testing of suspected cases and of imported animals continued for many years. In 1958, 1 horse among 16 that were tested in Ontario reacted to the subcutaneous mallein test. As a precautionary measure, the animal was classed as diseased and slaughtered, along with 6 contact horses. Compensation for the 7 animals amounted to \$700. Additional contacts were traced and mallein-tested, with negative results (34).

Laboratory support

The evolution of the Animal Pathology Division of the Health of Animals Branch of the Department of Agriculture, initially headed by Charles Higgins, has been described by Sayers (35). The main contribution of the division to the glanders eradication program was the preparation of mallein. In the early years, this product was purchased from the Chicago office of the Pasteur Institute, but in 1903, Higgins prepared 183 test doses of mallein in the Biological Laboratory in Ottawa (36), and

from 1906, all of the mallein used in the field was produced by this laboratory. In 1906, 14 303 test doses were issued, together with instructions for conducting the subcutaneous mallein test (37). The subcutaneous test was preferred throughout the eradication program, although, in the later years, mallein was also issued for intradermal and ophthalmic tests. Thus, of the 20 682 doses of mallein that were issued between April 1924 and March 1925, 12 022 were for the subcutaneous test, 3360 for the intradermal test, and 5300 for the ophthalmic test (38). During the first 20 years of the eradication campaign, the peak production of mallein was between April 1910 and March 1911, when 50 112 doses were issued (39), but this was exceeded in the final stage of the campaign when 90 765 doses were issued between April 1934 and March 1935, in support of the extensive testing associated with the control of the epidemic of glanders in the Eastern Townships of Quebec (40), although the number of doses issued greatly exceeded the number of actual tests.

In 1913, Higgins reported on research conducted by J.C. Reid on the use of the complement fixation test as a serological diagnostic procedure for glanders, but the method was found to be inferior to the mallein test (41). Complement fixation was, however, used by Edward Watson, who headed the Pathological Division from 1923, for the standardization of mallein (42). In the same report, Watson referred briefly to the use of an antiserum prepared in his laboratory for the treatment of human glanders, for which success was claimed in 3 cases in Manitoba. Ten years later, Watson and Reid refined the preparation of mallein by the use of a chemical culture medium in place of meat broth, which eliminated undesirable foreign proteins (43). The preparation of mallein continued for many years after glanders was eradicated, since all suspected cases continued to be tested.

Relatively few pathological or bacteriological investigations on glanders were conducted during the eradication campaign, partly due to the dangers to personnel associated with autopsies on glandered horses, and partly because the mallein test was well established as a reliable diagnostic procedure. An exception was a study made in 1934 by Charles Mitchell, J.C. Reid, and R.V.L. Walker on several horses that reacted to mallein in the outbreak in Quebec (44). This was done because there were few clinical cases in this outbreak, and the clinical signs were poorly marked. Lesions suggestive of glanders were found in 15 of the 16 horses that were examined. An isolate of *P. mallei* from 1 case was found to be indistinguishable antigenically from stock cultures of the organism, but in pathogenicity tests in guinea pigs and horses, it was shown to be of low virulence. Reid's earlier findings on the unreliability of the complement fixation test were confirmed, since several of the 16 horses were found to be serologically negative. The study reinforced the value of the mallein test as a means of detecting carriers of the infection.

Conclusions

The campaign for the eradication of glanders in Canada, initiated in 1904, was completed 34 years later. The

success of the campaign was a tribute to the work of John Rutherford, who put in place the necessary policies for eradication in the first decade of the 20th century, and to the efforts of the many field and laboratory workers of the Health of Animals Branch of the Department of Agriculture who brought the campaign to a successful conclusion, often under difficult circumstances. The campaign involved the slaughter of over 13 000 horses and the payment of over \$1 million in compensation. This was a small price to pay for the prevention of further losses to the horse industry from this devastating disease, and for the elimination of the hazard to human health from this important zoonosis.

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