HORSE TRICHINELLOSIS, AN UNRESOLVED PUZZLE

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Summary :

In spite of routine controls to detect *Trichinella* larvae in horse-meat, human infections due to horse-meat consumption continue to occur in France and Italy. The epidemiology of horse trichinellosis since its discovery in 1975 is outlined, addressing the possible modes of natural transmission to horses, the need to develop more sensitive methods for detecting *Trichinella* larvae in horses, and the economic impact of horse trichinellosis. Investigations of human outbreaks due to horse-meat consumption have implicated single cases of inadequate veterinary controls on horses imported from non-European Union countries. In particular, most cases of human infection have been attributed to horses imported from Eastern Europe, where pig trichinellosis is re-emerging and the main source of infection in horses.

KEY WORDS : horsemeat, outbreak, trichinellosis, epidemiology.

Experimental (in Germany and Austria) and natural (in Ohio, the USA) infections of horses with *Trichinella* date as far back as the 19th century (Gerlach, 1873; Csokor, 1884; Thornbury, 1897); however, the potential role of this domestic animal in the transmission of *Trichinella* infection to humans had been ignored until 1975, when a trichinellosis outbreak affected 89 persons who had eaten horse-meat in Italy. In the same year, another outbreak occurred in France, prompting the European Union (EU) to examine thousands of horses for the presence of *Trichinella* larvae, adopting the method used to detect this infection in pigs (i.e., artificial digestion of 1.0 g of diaphragm pillars). No natural infections in horses were detected at that time. Since 1975, human trichinellosis due to the consumption of horse-meat has accounted for 53.2 % (n = 3,326) of the total human cases (n = 6,250) of trichinellosis in the EU. Specifically, these infections have occurred in France (2,296 persons in eight outbreaks) and Italy (1,030 persons in six outbreaks), and each outbreak was attributed to the consumption of meat from single horses, imported from Canada, Former Yugoslavia, Mexico, Poland and the USA (Table I). Only in one of the 14 horses involved in these outbreaks had the routine examination at the slaughterhouse detected infection (Tamburrini *et al.*, 2001). The failure to detect infection in the other 13 horses was, in part, due to the fact that routine examinations were conducted on small quantities of muscle tissue (i.e., 1.0 g). Indeed, surveys using larger amounts of muscle tissue (i.e., 5-100 g) in tests detected *Trichinella* larvae in 12 horses originating from Mexico, Poland, Romania or Serbia (Table II).

THE HORSE-MEAT MARKET IN THE EUROPEAN UNION

France and Italy account for 71 % of the horse-meat consumed in the EU (39.4 and 77.0 × 1,000 tonnes per year, respectively), and they are the only two countries where horse-meat is eaten raw. The large amount of horse-meat, consumed mostly raw, can, in part, explain why infected horses have resulted in outbreaks only in these two countries. Worldwide, the prevalence of infection in horse populations appears to be very low: only 25 horses have been reported to have acquired this infection since 1975 (21 detected in France and Italy and four in Mexico). In the last 25 years, approximately six million horses have been consumed in the EU; thus the 21 infected animals represent an incidence of only 3.5/1 million slaughtered horses. The fact that the infected horses were imported from countries with a high prevalence of trichinellosis in pigs and/or wildlife suggests that there is, may be, a relation between the infection in these animals and that found in horses. Specifically, three infected horses detected in 1998, two of which were sources of human infections in France and one that was detected at the slaughterhouse in Italy, had been imported from Serbia where there are areas of high prevalence of domestic trichinellosis. Five infected horses (four detected at a slaughterhouse in Mexico in 1994 and one that was a source of infection in France the same year) were from Mexico and one from Romania (imported in Italy in 1996) where domestic trichinellosis is prevalent.

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Year	Locality (Country)	No. of human infections/death	Country of origin of the horse	*Trichinella* species
1975	Bagnolo in Piano (It)	89/0	Former Yugoslavia	*T. britovi*
1975	Chatenay-Malabry (Fr)	125/0	East Europe	n.d.[a]
1984	Varese (It)	13/0	Former Yugoslavia	n.d.
1985	Paris and Melun (Fr)	431/2	Connecticut (USA)	*T. murrelli*
1985	Paris and 10 other foci (Fr)	642/3	Poland	*T. spiralis*
1986	Salsomaggiore (It)	300/0	Former Yugoslavia	*T. britovi*
1990	Barletta (It)	500/0	East Europe	*T. spiralis*
1991	Clermont-Ferrand (Fr)	21/0	USA	n.d.
1993	Paris and 3 other foci (Fr)	538/0	Canada	*T. spiralis*
1994	Provins (Fr)	7/0	Mexico	*T. spiralis*
1998	Haute Garonne (Fr)	128/0	Serbia	*T. spiralis*
1998	Piacenza (It)[b]	93/0	Poland	*T. spiralis*
1998	Toulouse (Fr)	404/0	Serbia	*T. spiralis*
2000	Bitonto (It)	36/0	Romania or Poland	*T. spiralis*

[a] n.d. = not determined;
[b] The source of infection was a horse, which was found infected at the slaughterhouse in Brescia (Italy) in 1998.

Table I. – Outbreaks of human trichinellosis caused by infected horse-meat in France (Fr) and Italy (It).

Year	No. of infected horses	No. of larvae/g (examined muscle)	Locality where the infection was detected (country)	Country of origin of the horse	*Trichinella* species
1988	1	0.02 (biceps brachii)	Brescia (Italy)	Poland	n.d.[a]
1989	1	0.26 (diaphragm)	Brescia (Italy)	Former Yugoslavia	n.d.
1994	4	0.8, 1.0, 1.6 and 1.8 (diaphragm)	State of Mexico (Mexico)	Mexico	*T. spiralis*
1996	2	0.01, 0.02 (tongue)	Bordeaux (France)	Poland	n.d.
1996	1	11.0 (tongue)	Barletta (Italy)	Romania	*T. spiralis*
1998	1[b]	256.0 (diaphragm)	Brescia (Italy)	Poland	*T. spiralis*
1998	1	615.0 (tongue)	Poggio Imperiale (Italy)	Serbia	*T. spiralis*
1999	1	n.d.	France	Poland	*T. spiralis*

[a] n.d. = not determined;
[b] this is the same horse, which was the source of infection for the human outbreak that occurred in Piacenza (Italy) in 1998.

Table II. – Natural *Trichinella* infections detected in horses at the slaughterhouse during surveys (in Italy between 1988 and 1989; in Mexico in 1994) or during routine examinations.

NATURAL TRANSMISSION OF *TRICHINELLA* TO HORSES

Although there does not exist any epidemiological or scientific evidence of the natural modes of *Trichinella* transmission in horses, two hypotheses have been proposed: 1) grazing in pastures contaminated with infected rodent carcasses or pork scraps; and 2) ingesting infected flesh from pigs and wild carnivores. This second hypothesis is supported by the practice of using the carcasses of hunted or captive carnivores to fatten horses before slaughter and by the identification of larvae generally present in sylvatic carnivores (*Trichinella britovi* and *Trichinella murrelli*) from patients who acquired trichinellosis in three horse-meat outbreaks (Table II). Indeed, the use of proteins of animal origin in breeding herbivorous animals is now a common practice in many countries. Considering that the thickness of the collagen capsule increases with the age of the infection, the presence of thin capsules around the larvae in muscle tissues of the horse slaughtered in January and the presence of thick capsules in the larvae from horses slaughtered in April and October (Pozio *et al.*, 1999) seems to support the hypothesis that horses acquire this infection in late autumn or winter, either passively (i.e., by grazing in pastures contaminated by rodent carcasses or pork scraps), or actively (i.e., by fattening horses with infected swine meat).

DETECTION OF *TRICHINELLA* LARVAE IN HORSES

Between 1975 and 1990, testing for *Trichinella* larvae in local and imported horses was not mandatory in the EU. The mandatory testing of

fresh horse-meat produced in or imported to the EU was established by Directive 91/497/EEC of the European Community Council. Specifically, this directive specified that testing was to consist of the artificial digestion of 1 g of muscle tissue, according to the procedures used to detect this infection in pigs (Council Directive 77/96/EEC). In 1994, the minimum weight of the meat sample to be tested was increased from 1g to 5 g (Council Directive 94/59/EEC). Indeed, *Trichinella* larvae in slaughtered horses have only been found when conducting artificial digestion on at least 5-10 g of muscles (Pozio, 2001). Serological diagnosis is not acceptable as an inspection tool in horses, since five-six months after experimental infection, circulating antibodies disappear in sera, although there are still infective muscle larvae (Soulé *et al.*, 1989; Pozio *et al.*, 1997). It has been demonstrated that the muscles from the head of the horse constitute the predilection site for *Trichinella spiralis* larvae (Pozio *et al.*, 1999). In particular, the highest muscle burden in naturally infected animals has been found in *Musculus buccinator*, *Lingua*, *Musculus levator labii maxillaris*, and *Musculus masseter*. Compared to the diaphragm, the number of larvae per g is 3.5 to 6.8 times higher in *Lingua*, 3.5 to 6.5 times higher in *M. levator labii maxillaris*, and 2.5 to 4.6 times higher in *M. buccinator*. The diaphragm, which is still the most common muscle used for detecting *Trichinella* in horses, never ranks higher than the 6th position among the predilection muscles for the diagnosis of this infection (Pozio *et al.*, 1999). Published data from experimental infection in horses confirm these results (Soulé *et al.*, 1989; Gamble *et al.*, 1996).

ECONOMIC IMPACT OF HORSE TRICHINELLOSIS

The estimated total cost of testing for trichinellosis in slaughterhouses is 10-20 euros per horse (Boireau P., personal communication), which means that the EU spends at least 5,000,000 euros per year. It should be pointed out that the EU spends more than 99 % of the funds allocated to trichinellosis control on screening those animals that are the source of less than 50 % of human infections, whereas only 0.8 % of the funds are used to screen horses, which are the source of more than 50 % of human infections. The cost for each human infection has been estimated at 6,000 euros (Roberts *et al.*, 1994). In the last 25 years, the total cost of the 3,300 human infections in France and Italy due to the consumption of horse-meat has been 19,800,000 euros, which is more than the total cost of human infections caused by pork or game meat. A horse carcass generally weighs 350 kg or more and the meat from one horse can be eaten by hundreds of people. Horse-meat intended to be consumed raw should be inspected by the most reliable methods (i.e., testing the largest amounts of tissue possible and applying high-level quality control in the screening). Indeed, the control methods of the EU (Council Directive 77/96/EEC) can ensure the prevention of clinical trichinellosis in humans but not infection with few infective larvae.

CONCLUSIONS

Epidemiological investigations of the most recent four human outbreaks have shown that they occurred because of inadequate veterinary controls at the slaughterhouse. Horse-meat outbreaks have important consequences on public health (a high number of infected persons, some of them with a very severe symptomatology, at times resulting in death). They also have a great impact on medical costs, on the horse-meat market (a collapse in sales of horse meat after each outbreak), and in legal and administrative terms (implementation of control measures at the national and international levels, etc.) (Ancelle, 1998).

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