Summary:

Human trichinellosis in the European Union due to insufficiently cooked horse meat consumption has been reported in France and in Italy during the past 25 years. It occurred in several outbreaks totalling more than 3,000 patients during this period, with a low mortality and a high morbidity. Causative Trichinella species or phenotypes were determined by the International Reference Laboratory for Trichinellosis in Rome, Italy. They were: Trichinella spiralis, T. britovi and T. murrelli. As the culinary habits and customs of populations cannot be changed by regulations, measures of protection of public health essentially depend on food inspection. Comprehensive studies having been conducted in the pathophysiology of Trichinella infection in horses; it was demonstrated that the localisation of larvae are quite different in horses and in pork. It resulted an instruction from the French Veterinary Service recommending that:

- the sampling of muscles in horses carcasses has to be done at first in the tongue (apex), then in the diaphragm (pillars);
- at least 50 g have to be sampled in each site;
- examination for larvae has to be done with the digestion method.

Such recommendations might be extended to other EU member countries then to the OIE Zoosanitary Code.

Key Words: trichinellosis, food inspection, horse meat.

Background: An Outline of Our Current Knowledge on Trichinella spp.

Several books and review articles (Dupouy-Camet et al., 1992; Euzéby, 1999; Soulé et al., 1991; Touratier, 1998) give a comprehensive description of the infection. The disease has a mild prognosis in animals but is a serious disease (Ancelle et al., 1988; Haeghebaert et al., 1998; Magnaval et al., 2000) when it occurs in humans. The causative nematode Trichinella (Railliet, 1895) spiralis, was for a long time considered as a unique species of the genus Trichinella. The belief in the unity of the species T. spiralis was broken formerly by isoenzymatic then by nucleic comparisons of hundreds of isolates or strains originating from the five regions of the world at the Trichinella Reference Centre Istituto Superiore di Sanità in Rome, Italy. Henceforth the following species are recognised: T. spiralis, T. nativa, T. britovi, T. pseudospiralis, T. papuae, T. nelsoni, T. murrelli and two phenotypes of uncertain taxonomic level: T6 and T8.

Origin of Infection: Studies Carried Out on Horses

Human Outbreaks 1975-1998

Human trichinellosis in France was considered to depend on consumption of insufficiently cooked contaminated pork and disappeared since the last important outbreak of Crépy-en-Valois in 1876/1877 (Laboulbène, 1881). But, in 1975 and 1978 numerous cases of trichinellosis and actual outbreaks occurred progressively in France and Italy after horse meat consumption (Mantovani et al., 1976; Bourée et al., 1979). Characterisation of larvae recovered from patients or domestic animals fed with infected horse meat from the Italian and French outbreaks in 1985 indicated that...
both *T. spiralis* and sylvatic species can infect horses (de Carnieri *et al.*, 1989; Dick *et al.*, 1990; Dupouy-Camet *et al.*, 1988).

**EXPERIMENTAL STUDIES ON HORSE INFECTION**

At the end of the 19th century the experimental infection of a horse with *T. spiralis* originating from rats living in an abattoir was achieved in Vienna. Then, nearly a century later, various authors carried out experimental infection of horses with several isolates of *Trichinella spp.* These larvae were produced either in rats for *T. spiralis* isolates or in mice for *T. britovi* isolates, for example for CTRD 85 (later identified as *T. murrelli*) strain which was isolated from a human biopsy during the trichinellosis outbreak of August 1985 in France and which was used to infect nine horses (Soule, 1993). Depending on protocols applied by respective authors each experimental horse was slaughtered and necropsied from three to 52 weeks post infection and the meat was submitted to meticulous inspection to look for encapsulated larvae (Gamble, 1998; Gamble *et al.*, 1998; Mantovani *et al.*, 1976; Soule, 1993). The sites of predilection of *Trichinella spp.* larvae were compared in pigs and horses for determining the best choice of muscle sampling. Techniques used for enumerating infective larvae were either artificial digestion or trichinoscopy. Sizes of muscle samples varied from 5 g to 100 g for artificial digestion and from 0.5 g to 1 g for trichinoscopy.

IgG antibodies were identified from the second until the 16th or the 40th week post infection either by indirect immunofluorescence assay (IFI) or by enzyme immunoassay (EIA = ELISA). Thus these techniques are only valid for diagnosing early infections before the 40th week but cannot be recommended at the slaughterhouse where old horses with old infestation can be slaughtered. There is a difference with pigs in which detection times by EIA varied from four to eight weeks post-infection (Pozio *et al.*, 1988).

**NATURAL INFECTION OF HORSES**

It has been hypothesised (Grétillat, 1985) that – for the domestic cycle of *T. spiralis* – horses could ingest forage spoiled by rodent faeces which would have been themselves *Trichinella* infected and which would eliminate adult forms of the worm after several re-infections. But this phenomenon would be extremely unlikely for horses as the threshold of infection for this animal species is 10,000 L₁ larvae (Soulé, 1993) which is not possible through faeces contamination.

It has been suggested that horse infection can occur by accidental ingestion of contaminated rodents or meat ground up with hay or feed (Dupouy-Camet *et al.*, 1994). Anyway natural infection of horses was observed at slaughterhouse by careful meat inspection, taking into account experimental data as well as the site and the size of muscle sampling in combination with the method of artificial digestion. Most infected horses were found in Italy but also in Mexico and France (Table I). All these findings (experimental and practical data) gave rise to new French regulations (see below).

**BETTER UNDERSTANDING OF HUMAN OUTBREAKS OF TRICHINELLOSIS DUE TO HORSE MEAT CONSUMPTION**


### Table I. – Naturally infected horses detected at slaughterhouse.

<table>
<thead>
<tr>
<th>Year</th>
<th>Larvae</th>
<th>Towns and countries of detection</th>
<th>Origin of horses</th>
<th>Trichinella</th>
</tr>
</thead>
<tbody>
<tr>
<td>1988</td>
<td>1 (0.02)</td>
<td>Brescia - Italy</td>
<td>Poland</td>
<td>n.i.¹</td>
</tr>
<tr>
<td>1989</td>
<td>1 (0.26)</td>
<td>Brescia - Italy</td>
<td>Yugoslavia</td>
<td>n.i.</td>
</tr>
<tr>
<td>1994</td>
<td>1⁴</td>
<td>State of Mexico - Mexico</td>
<td>Mexico</td>
<td>T. spiralis</td>
</tr>
<tr>
<td>1996</td>
<td>1 (0.01)</td>
<td>Bordeaux - France</td>
<td>Poland</td>
<td>n.i.</td>
</tr>
<tr>
<td>1996</td>
<td>1⁵</td>
<td>Barletta - Italy</td>
<td>Romania</td>
<td>T. spiralis</td>
</tr>
<tr>
<td>1998</td>
<td>410⁶</td>
<td>Brescia - Italy</td>
<td>Poland</td>
<td>T. spiralis</td>
</tr>
<tr>
<td>1998</td>
<td>1200⁷</td>
<td>Poggio Imperiale - Italy</td>
<td>Yugoslavia</td>
<td>T. spiralis</td>
</tr>
<tr>
<td>1999</td>
<td>5⁸</td>
<td>Carpentras - France</td>
<td>Poland</td>
<td>T. spiralis</td>
</tr>
</tbody>
</table>

¹In biceps brachii (0.02 larvae/g.) and in diaphragm (0.26 larvae/g.) Boni *et al.*, 1989.
²Arriga *et al.*, 1995.
³In the tongue (C. Soule, personal communication).
⁴Predominance of labial muscles.
⁵Predominance of labial muscles and high infections in diaphragms (255 and 166 l/g).
⁶Non identified.
⁷Predominance of labial muscles (P. Boireau, personal communication).
ADDITIONAL DATA ON SENTINEL
AND COMPANION ANIMALS

Sometimes parasite burdens in patients are too low to obtain an isolate of the parasite in rodents as it was the case for the 1993 outbreak in France (Dupouy-Camet et al., 1994). However, the isolate was obtained from a biopsy carried out on a cat living with a family of patients (18 living larvae which could be compared by conventional PCR and RAPD with the DNA of a single dead larva isolated from a patient). A similar case already mentioned above, was described for the 1998 outbreak (Perret et al., 1999). Dogs can also harbour Trichinella cysts for long periods as it was recorded in 1994 (Touratier et al., 1994) quoting the case of a dog living in a restaurant and having eaten infected meat from wild boars in France. From their side Italian authors mentioned the presence of Trichinella larvae in three dogs out of eight having eaten infected horse meat during outbreaks of Bagnolo di Piano in 1975 (Mantovani et al., 1976).

CONSEQUENCES OF EPIDEMICS OF HUMAN TRICHINELLOSID ON HORSE MEAT CONSUMPTION

As the danger of the Trichinella infected horse meat for human consumption depends on the culinary habits and customs of people it would be easy to prevent this infection by properly cooking horse meat. In this respect Table III clearly shows that no human trichinellosis cases have been reported in Belgium, Luxemburg and The Netherlands where horse meat consumption per inhabitant and per year is nearly the same as in France and in Italy. However, human behaviours cannot be subjected to regulations.

Social cost

From a survey carried out in France in 1990 (Ancelle et al., 1990) on the cost of outbreaks which occurred in 1985 as far as Public Health was concerned, each patient “cost” was € 1,500 (1,073 patients in 1985). The human cost (five deaths, two abortions and 100 serious cases with cardiac and neurological complications) should also be considered.

Disaffection of the people for horse meat

In the five countries of the EU where horse meat has the highest consumption (more than 1 kg per inhabitant and per year in 1982) a steady decrease has been observed between 1982 and 1999 (Table III).

PROBLEM

OF HORSE MEAT/CARCASS INSPECTION
AND OTHER CONTROL MEASURES

RECOMMENDATIONS
OF THE OFFICE INTERNATIONAL OF EPIZOOTIES

In the “Manual of Standards for Diagnostic Tests and Vaccines” (OIE, 1996) identification techniques of Trichinella spp. were described either by trichinoscopy or by artificial digestion of muscle samples from pigs and horse meat.

<table>
<thead>
<tr>
<th>Date</th>
<th>Place</th>
<th>Number of cases</th>
<th>Origin of horses or meat</th>
<th>Type of isolated Trichinella</th>
<th>References</th>
</tr>
</thead>
<tbody>
<tr>
<td>1975</td>
<td>Bagnolo in Piano - Italy</td>
<td>89</td>
<td>Yugoslavia</td>
<td>T. britovi</td>
<td>Mantovani et al., 1980</td>
</tr>
<tr>
<td>1984</td>
<td>Varese - Italy</td>
<td>13</td>
<td>Yugoslavia</td>
<td>T. spiralis</td>
<td>Parravicini et al., 1986</td>
</tr>
<tr>
<td>1985</td>
<td>Paris and Melun - France</td>
<td>431</td>
<td>USA</td>
<td>T5</td>
<td>Ancelle et al., 1988</td>
</tr>
<tr>
<td>1985</td>
<td>Paris and neighbourhoods - France</td>
<td>642</td>
<td>Eastern Europe (Poland?)</td>
<td>T. spiralis</td>
<td>Ancelle et al., 1988</td>
</tr>
</tbody>
</table>

Table II. - Outbreaks of human trichinellosis in Europe due to raw or lightly cooked horse meat consumption (1975-1999). (More than 3,000 infested people – five deaths occurred in the two outbreaks of 1985 in France. Many data provided by Professor J. Dupouy-Camet).
In the “O.I.E. International Zoo-sanity Code” only one paragraph is devoted to horse meat inspection and to the identification of *T. spiralis* (OIE, 1999).

**FRENCH REGULATIONS**

According to an internal instruction of the French National Veterinary Service N2000-8029 (Note de Service DGAL, 2000) it has been decided: to inspect two samples of at least 50 g each in the predilection sites of *Trichinella* larvae in horses carcasses, one at the extremity of the tongue (apex) and the other one in the pillars of the diaphragm.

**CONCLUSIONS**

According to the main data collected it was shown that:
- Natural infection of horses with *Trichinella* spp. has never been reported in countries of Western Europe;
- Serology procedures cannot be used to detect infected horse meat at the abattoir as IgG antibodies may disappear after 40 weeks of infection;
- Microscopic examination of the cyst wall help in evaluating the “age” of the infection by thickness of the wall;
- The sample size of muscle tissue seems to be directly related with the success of identifying muscular infective larvae (Note de Service DGAL, 2000);
- Predilection sites for sampling are different in horse carcasses in comparison with those commonly used for pig carcasses;
- The artificial digestion method should be used exclusively for the examination of muscle tissue for *Trichinella* larvae.

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**REFERENCES**


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**Consumption:**

<table>
<thead>
<tr>
<th></th>
<th>1982</th>
<th>1993</th>
<th>1999</th>
</tr>
</thead>
<tbody>
<tr>
<td>Belgium and</td>
<td>(*) 3.23</td>
<td>(*) 1.6</td>
<td>(*) 1.3</td>
</tr>
<tr>
<td>Luxemburg</td>
<td>(**) 30</td>
<td>(**) 17</td>
<td>(**) 16.2</td>
</tr>
<tr>
<td>Netherlands</td>
<td>(*) 1.97</td>
<td>(*) 1.6</td>
<td>(*) 1</td>
</tr>
<tr>
<td>France</td>
<td>(**) 23</td>
<td>(**) 16</td>
<td>(**) 12</td>
</tr>
<tr>
<td>Italy</td>
<td>(*) 1.59</td>
<td>(*) 0.75</td>
<td>(*) 0.5</td>
</tr>
<tr>
<td></td>
<td>(**) 77</td>
<td>(**) 42</td>
<td>(**) 30.8</td>
</tr>
<tr>
<td></td>
<td>(*) 1.34</td>
<td>(*) 1.42</td>
<td>(*) 1.3</td>
</tr>
<tr>
<td></td>
<td>(**) 54</td>
<td>(**) 76</td>
<td>(**) 68</td>
</tr>
</tbody>
</table>

**Number of confirmed cases of human trichinellosis (origin "horse") from 1975 to 1998**

<table>
<thead>
<tr>
<th></th>
<th>Range of cooking</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
</tr>
<tr>
<td>Belgium and</td>
<td>- well done</td>
</tr>
<tr>
<td>Luxemburg</td>
<td>- well done</td>
</tr>
<tr>
<td>Netherlands</td>
<td>2,299 raw or slightly cooked</td>
</tr>
<tr>
<td>France</td>
<td>994 raw or slightly cooked</td>
</tr>
</tbody>
</table>

**Remark:** Consumption of other EU countries from 1993 onwards
- Greece, UK: none
- Germany, Denmark and Portugal: less than 0.1 Kg/inhabitant/year
- Austria, Spain, Finland, Sweden: from 0.2 to 0.4 Kg/inhabitant/year. Meat cooking: especially well done.


