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Parasites ramble on: Focus on food security

Searching for *Trichinella*: not all pigs are created equal

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Each year, millions of pigs worldwide are tested for *Trichinella* spp. at slaughterhouses with negative results. Yet, thousands of people acquire trichinellosis by consuming pork. So, where is the problem? Testing for *Trichinella* spp. is often performed on the 'wrong' animals; while the parasites are mainly circulating in backyard and free-ranging pigs, herds kept under controlled management conditions are the ones tested. Veterinary services should: (i) introduce a risk-based surveillance system for *Trichinella* by documenting the control of housing conditions and feedstuff sources, and (ii) introduce a capillary network of field laboratories for monitoring the parasites in free-ranging and backyard pigs. Investment of funds into the education of farmers, hunters, and consumers should be a priority for public health services.

Notions for defining the *Trichinella* problem in pigs

Nematode worms of the genus *Trichinella* are zoonotic parasites with a cosmopolitan distribution on all continents but Antarctica [1]. These pathogens are the etiological agents of trichinellosis, a serious, sometimes fatal, human disease, which has been documented in 55 countries of the world [2,3]. Humans acquire the infection by the ingestion of raw or semi-raw meat and meat derived products from domestic pigs, horses, dogs, and wild animals (e.g., wild boars, bears, badgers, and walruses) [3]. At the country level, the occurrence of *Trichinella* spp. in domestic and/or wild animals is a necessary but not sufficient condition for the occurrence of trichinellosis. Food behavior is the main risk factor to acquire this zoonotic infection [4].

At present, nine species and three genotypes divided into two clades are recognized in the genus *Trichinella* [1]. All taxa are potentially zoonotic, but to date only six species and one genotype have been detected in humans [1,2]. More than 100 species of mammals, birds, and reptiles are known hosts of *Trichinella* parasites [5]; although most are wild animals, these parasites have also been detected in domestic pigs, horses, dogs, and cats [5].

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Keywords: pigs; *Trichinella*; backyard; free-ranging; risk-based surveillance; audit; controlled housing.

1471-4922/$ – see front matter

 http://dx.doi.org/10.1016/j.pt.2013.11.001

In 1860, the German pathologist F.A. Zenker first identified the domestic pig as a possible source of infection for humans. Over the next few years, the domestic pig was identified as the main reservoir of *Trichinella spiralis*, and pork was recognized as the main source of trichinellosis for humans, both of which have substantial consequences for public health and the meat trade [6]. In 1863, the German state of Ducky of Brunswick introduced mandatory inspection of pig carcasses for *Trichinella* larvae by a hand lens and a microscope at 100× magnification. By the end of the 19th century, the trichinoscopy of slaughtered pigs had become common in Germany and in much of Western Europe. In the USA, the trichinoscopy examination of pig carcasses was introduced in Chicago in 1891 for pork exported to Europe, but not for the local market [6].

Before World War II, trichinellosis caused by the consumption of infected pork continued to be an important public health concern with thousands of cases in North, Central, and South America (mainly in the USA, Mexico, Argentina, and Chile), and in Europe (mainly in Germany, Poland, Romania, Spain, and former Yugoslavia) [7]. Following the War, the prevalence of *Trichinella* spp. in domestic pigs was drastically reduced, owing to the improvement of rearing practices in most pig production. However, even in industrialized countries where the majority of pigs originate from herds kept under controlled management conditions, there is almost always a percentage of them that often elude veterinary oversight, for example, backyard and free-ranging animals. Thus, thousands of people end up acquiring trichinellosis by consuming pork from these animals. Furthermore, there are several examples where countries had suitable controls in place for parasite management in domestic pigs, but changes in pork production affected by socioeconomic conflicts have resulted in the reemergence of trichinellosis as a serious public health problem [8,9].

Epidemiology of *Trichinella* spp.

Trichinella spp. are transmitted from one animal to another, or to a human, solely by the ingestion of muscle tissues infected with encysted *Trichinella* larvae. Wild mammals serve as the major reservoir hosts, and the role of wildlife is underscored by the biomass of the parasites, which is greater in wild than domestic animals, unlike other nematode infections that involve both sylvatic and domestic animals. When humans fail to properly manage domestic pigs and wildlife, *Trichinella* spp., particularly

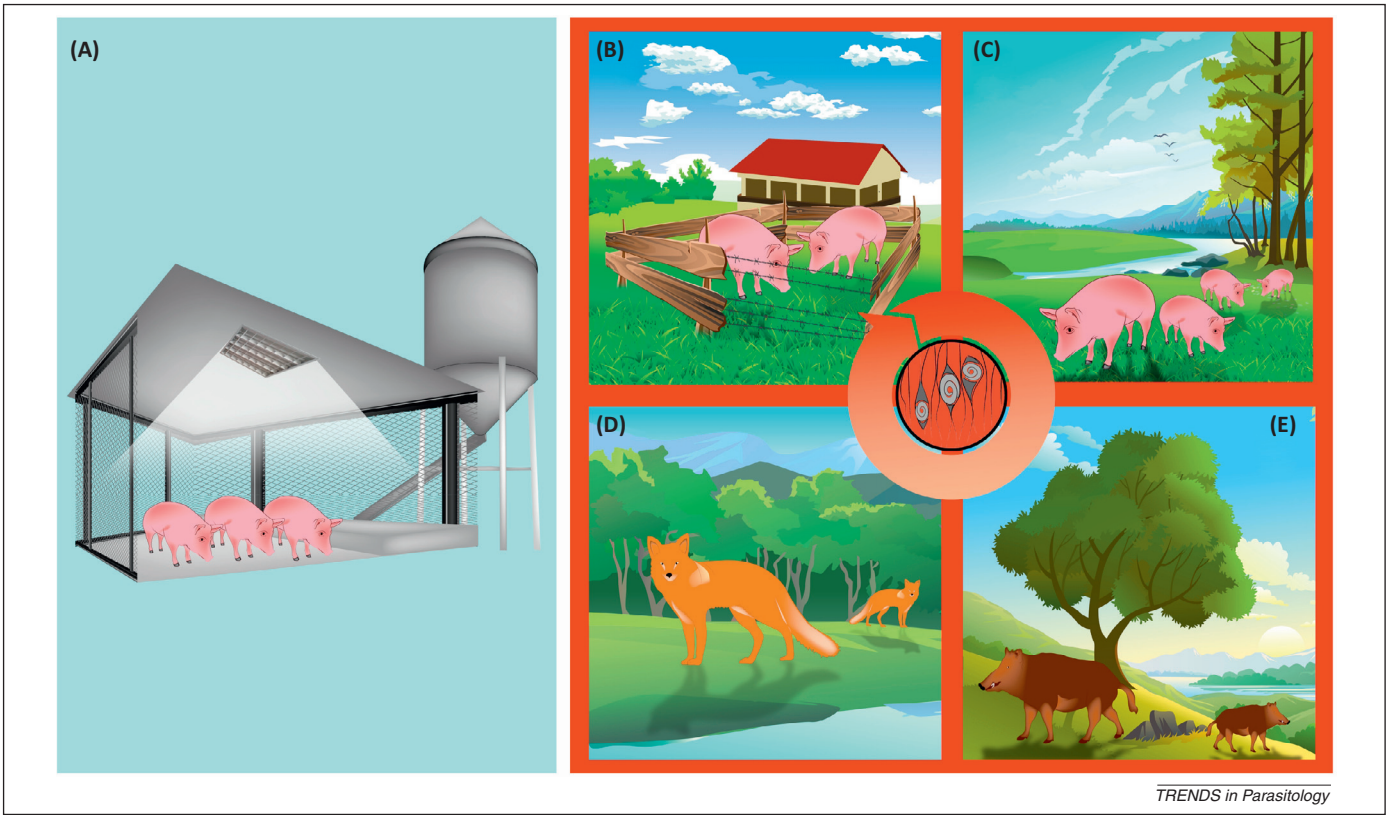

Figure 1. Pig-rearing practices and *Trichinella* spp. transmission. When humans fail in the proper management of domestic animals and wildlife, *Trichinella* (especially *T. spiralis*) infection is transmitted from the sylvatic to the domestic environment. In addition, *Trichinella* species can be transferred in a reversible path from domestic animals to wildlife. **(A)** Pigs under controlled housing conditions; *Trichinella* spp. larvae have never been detected in these pigs, which should not be tested or monitored for *Trichinella* spp. infections. Veterinary services ensure the good rearing practices by farm audits. **(B)** and **(C)** are backyard and free-ranging pigs, respectively; these pigs are at high risk for *Trichinella* spp. infections. **(D)** and **(E)** are wild carnivorous and omnivorous mammals, respectively. These animals are the natural reservoirs of most *Trichinella* species.

T. spiralis, are transmitted from the sylvatic to the domestic environment, triggering the onset of the domestic cycle. This cycle occurs where there are high-risk farming practices, such as the intentional feeding of food waste, which may contain pork scraps, or unintentionally through exposure to carcasses of dead swine or infected wildlife; unsecured, free-range pasturing is typically to blame [10]. Farming practices at risk for *Trichinella* spp. transmission occur, in general, in disadvantaged and poor areas where veterinary services do not exist or are unable to control the myriad of small pig units (Figure 1).

A comprehensive epidemiological picture of the domestic transmission cycle also includes other sources: (i) pigs allowed to scavenge in garbage dumps; (ii) feeding of wild game carcasses or scraps from hunting; and (iii) the use of carcasses of slaughtered fur animals as feed (Box 1). The intersection of hunters, the manner in which they deal with wild game carcasses, and free-ranging and/or backyard pig farming practices combine to perpetuate infection with *Trichinella* spp.

Global pig production

According to the Food and Agricultural Organization (www.fao.org/ag/againfo/themes/en/pigs/home.html), out of all terrestrial animals, pork meat has the highest consumption worldwide. In recent decades, changes in consumption patterns have pushed up the demand for pork as incomes have increased in developing countries with fast-growing economies. The global yearly pig production is forecast to reach 1 billion by 2015, which is double compared with the 1970s; approximately half of the pigs are raised in China.

Pig production is global, except for some regions with cultural and religious reservations regarding the consumption of pork and is characterized by an increasing dichotomy of production systems: traditional subsistence-driven small-scale production on the one side, and specialized industrial farming on the other. Indoor farms are now responsible for more than half of the global pig production, but indoor farming alone does not prevent *Trichinella* spp. transmission if controlled management conditions are not in place.

Trichinella species infecting swine

Because *Trichinella* spp./genotypes lack or differ in the level of infectivity to pigs, it is important to know what taxon/taxa is/are circulating or can be introduced into a country by different hosts (Figure 2). Out of the 12 taxa of the *Trichinella* genus, *T. spiralis* is the species better adapted to, and more frequently detected in swine (both domestic and sylvatic), in which it can reach a high worm burden (up to 8000 larvae/g in the diaphragm pillar) without causing clinical disease [1]. Moreover, *T. spiralis* shows a cosmopolitan distribution because humans have passively introduced it on most continents by animal movement, increasing the risk for public health [11,12].