Veterinary Parasitology 213 (2015) 24–37

Contents lists available at ScienceDirect

Veterinary Parasitology

journal homepage: www.elsevier.com/locate/vetpar

The role of wild canids and felids in spreading parasites to dogs and cats in Europe. Part II: Helminths and arthropods

Domenico Otranto[a,*], Cinzia Cantacessi[b], Filipe Dantas-Torres[a,c], Emanuele Brianti[d], Martin Pfeffer[e], Claudio Genchi[f], Vittorio Guberti[g], Gioia Capelli[h], Peter Deplazes[i]

[a] Dipartimento di Medicina Veterinaria, Universita' degli Studi di Bari, 70010 Valenzano, Italy
[b] Department of Veterinary Medicine, University of Cambridge, CB3 0ES Cambridge, United Kingdom
[c] Departamento de Imunologia, Centro de Pesquisas Aggeu Magalhães, Fiocruz-PE, Recife, Brazil
[d] Dipartimento di Scienze Veterinarie, Universita' degli Studi di Messina, 98168 Messina, Italy
[e] Institute of Animal Hygiene & Veterinary Public Health, University of Leipzig, 04103 Leipzig, Germany
[f] Dipartimento di Scienze Veterinarie e Sanita' Pubblica, Universita' degli Studi di Milano, 20133 Milano, Italy
[g] Istituto Superiore per la Protezione e la Ricerca Ambientale, 40064 Ozzano dell'Emilia, Italy
[h] Istituto Zooprofilattico Sperimentale delle Venezie, 35020 Legnaro, Italy
[i] Institute of Parasitology, University of Zürich, 8057 Zürich, Switzerland

ARTICLE INFO

Article history:
Received 13 April 2015
Accepted 22 April 2015

Keywords:
Arthropods
Helminths
Wildlife
Europe
Wild canids
Wild felids
Zoonoses
Echinococcus multilocularis
Thelazia callipaeda
Dirofilaria
Onchocerca lupi
Toxocara canis
Aelurostrongylus abstrusus
Troglostrongylus brevior
Angiostrongylus vasorum

ABSTRACT

Over the last few decades, ecological factors, combined with everchanging landscapes mainly linked to human activities (*e.g.* encroachment and tourism) have contributed to modifications in the transmission of parasitic diseases from domestic to wildlife carnivores and *vice versa*. In the first of this two-part review article, we have provided an account of diseases caused by protozoan parasites characterised by a two-way transmission route between domestic and wild carnivore species. In this second and final part, we focus our attention on parasitic diseases caused by helminth and arthropod parasites shared between domestic and wild canids and felids in Europe. While a complete understanding of the biology, ecology and epidemiology of these parasites is particularly challenging to achieve, especially given the complexity of the environments in which these diseases perpetuate, advancements in current knowledge of transmission routes is crucial to provide policy-makers with clear indications on strategies to reduce the impact of these diseases on changing ecosystems.

1. Helminths and arthropods of wild and domestic carnivores: a complex scenario

With a few exceptions in some areas, knowledge of the ecology and epidemiology of helminths and arthropods shared by wild and domestic carnivores in Europe is limited. One of the exceptions is represented by the tapeworm *Echinococcus multilocularis*, the causative agent of zoonotic alveolar echinococcosis, for which extensive data on its the ecology in rural and urban habitats is available for central Europe (Deplazes et al., 2004; Hegglin et al., 2015; Raoul et al., 2015). In addition, like protozoans, parasitic helminths are also characterised by complex life cycles, often involving a range of intermediate (*e.g. Aelurostrongylus*, *Troglostrongylus*, *Angiostrongylus* and *Opisthorchis*) and paratenic hosts (*i.e. Toxocara*), which makes the identification of potential hazards of cross-transmission between wild and domestic carnivores and *vice versa* particularly challenging. This scenario is further complicated by the plague represented by the illegal trade of wildlife species into Europe (often carrying parasites) (Davidson et al., 2013) which, coupled with the ever-increasing human and pet travel, represents a

* Corresponding author. Tel.: +39 80 4679839; fax: +39 80 4679839.
E-mail address: domenico.otranto@uniba.it (D. Otranto).

http://dx.doi.org/10.1016/j.vetpar.2015.04.020
0304-4017/

serious obstacle to the implementation of control strategies aimed at preventing the cross-transmission of helminths and arthropods from wild to domestic carnivores (and humans). In the second of this two-part article, we provide an overview of key diseases caused by parasitic helminths and arthopods shared by domestic and wild canids and felids (with a particular focus on those with potential public health implications) and discuss a potential way-forward towards controlling the spread of these diseases (as well as those caused by protozoan parasites) *via* combined efforts of veterinarians, physicians, microbiologists, biologists and health policy-makers.

2. Helminths infecting domestic and wild carnivores

2.1. Taeniids

2.1.1. Echinococcus granulosus *complex*

The taxonomy of *Echinococcus* spp. (Cestoda, Taeniidae), causing cystic echinococcosis (CE) in intermediate hosts (mainly wild and domestic large herbivores and omnivores) and humans, is still under revision (Lymbery et al., 2015; Romig et al., 2015). CE is an important zoonosis still persisting in Southern Europe and the Balkans and emerging in Eastern European countries and in the Baltic region (Marcinkutė et al., 2015), with severe clinical implications (Stojkovic et al., 2014). In Europe, *E. granulosus* sensu stricto (sheep strain, genotypes G1-3) represents the principal agent of zoonotic CE affecting humans (mainly in Southern and South-Eastern Europe) with a considerable burden of disease. *Echinococcus intermedius* (*E. granulosus* pig strain, G7) is the main agent of human CE in countries of the Baltic region, Poland and parts of Eastern Europe (Marcinkutė et al., 2015), with sporadic cases recorded in other European areas (Sardinia, Spain, and Portugal). *Echinococcus canadensis* (cervid strain, G8 and G10) occurs in the circumpolar North, including Sweden, Finland and Estonia.

The life cycles of the CE species-complex in Europe rely on canids (mainly the domestic dog) as definitive hosts, and a range of large herbivorous and omnivorous species as intermediate hosts. Large wild canids are susceptible to *E. granulosus* s.l. and can contribute significantly to disease epidemiology and zoonotic transmission (*e.g.* the dingo in Australia; Jenkins et al., 2005). For *E. canadensis*, possibly overlapping transmission cycles have been described: "the original wolf- wild cervid (reindeer or elk) -cycle; the semi-synanthropic cycle involving sled and hunting dogs and wild cervids; and the synanthropic cycle involving herding dogs and semi-domesticated reindeer" (Oksanen and Lavikainen, 2015). In the intermediate hosts, including humans (rare cases with low pathogenicity), cysts predominantly appear in the lungs. Actually, the wolf-cervid cycles sustain the parasite in Fennoscandia. However, feeding hunting and sled dogs raw meat or offal can sporadically cause patent infections with zoonotic potential.

Patent *E. granulosus* (s.l. or G1) infections have been detected in jackals (Takács et al., 2014; Breyer et al., 2004) and in wolves in Southern Europe (Italy, Guberti et al., 2004; Gori et al., 2015; Spain, Sobrino et al., 2006). A sylvatic cycle of *E. intermedius* involving wild boars and wolves was hypothesized to occur in a Portuguese national park (Guerra et al., 2013); in Spain, a wild boar infected with fertile *E. granulosus* (G1) cysts was detected in a region inhabited by wolves (Martín-Hernando et al., 2008). In addition, in Italy (Apennine region), a semi-domestic life cycle involving sheep and wolves has been proposed (Guberti et al., 2004). Spatial behaviour (large home ranges and long dispersion distances) of these large canids promotes the spread of this parasite throughout Europe. On the other hand, in Europe, infected foxes are only rarely detected (and usually with low burdens of *E. granulosus* s.l.) and are therefore considered of marginal importance for parasite transmission.

Fig. 1. The red fox (*Vulpes vulpes*) is the most abundant and widespread canid species in Europe (courtesy of Adriano De Faveri).

Domestic and wild felids are not susceptible to intestinal infections with CE species occurring in Europe, but can suffer from CE, although very rarely (Armua-Fernandez et al., 2014).

In Europe, control of CE focuses on the domestic life cycles of the parasite, *via* veterinary public health measures including control of stray dogs and dog deworming campaigns (Craig and Larrieu, 2006). While continuous recommendations are made to refrain from feeding dogs offal of hunted or home slaughtered animals and to regularly administer dog deworming treatments, these are often neglected.

2.1.2. *Echinococcus multilocularis*

E. multilocularis is a small tapeworm of carnivore definitive hosts whose cycle includes a range of rodent intermediate hosts (bearing the metacestode stage) and relies on a predator-prey relationship. The complex parasite ecology is intimately linked to the dynamics of the prey population and to the dietary needs of the predators (Raoul et al., 2015). Humans and a range of animals (*e.g.* pigs, a variety of monkey species, dogs and others; Deplazes and Eckert, 2001) are accidental hosts. Alveolar echinococcosis (AE) is one of the most severe parasitic zoonoses in Europe and in the Northern Hemisphere, with very serious clinical implications and high burden of disease (Stojkovic et al., 2014; Torgerson et al., 2008). The range of occurrence of *E. multilocularis* is still expanding across Europe, and growing red fox populations (Fig. 1) and colonisation of residential areas by these carnivores are major determinants of the progressive urbanisation of the parasite life cycle (Liccioli et al., 2015). This, in turn, contributes to a significant increase of the infection risk to dogs hunting infected voles and to human populations exposed to an *E. multilocularis*-contaminated environment (Deplazes et al., 2004). Several studies have reported an increase in human AE incidence in Austria, Switzerland, France, Poland and Lithuania (Gottstein et al., 2015; Marcinkutė et al., 2015). In Switzerland, an average twofold increase of the annual incidence was documented in 2001–2005 (10–15 years since a significant expansion of fox populations) when compared with that recorded in 1993–2000 (Schweiger et al., 2007). Besides known highly endemic areas for AE (Southern Germany, Eastern France and Switzerland), cases of AE are increasingly being reported from Lithuania and parts of Poland, which are now considered 'new' endemic areas (Marcinkutė et al., 2015); therefore, the emergence of AE in areas previously considered 'disease-free' should not be underestimated (Gottstein et al., 2015).

Canid species (particularly the red fox) are the most important definitive hosts of *E. multilocularis*. Small numbers (<50) of mostly non-gravid worms have occasionally been detected in wild felids and in domestic cats (Deplazes et al., 2011; Deplazes, 2015).