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Current Status and Impact of Animal Parasitic Nematodes : A Review

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ABSTRACT

Nematodes are the most abundant metazoans on this planet that have been reported from all terrains of all the continents. They are free-living as well as parasitic, living in both plants and animals. Parasitic nematodes are most important because they severely affect their host thereby causing significant economic loss. The animal parasitic nematodes cause several debilitating diseases in human, livestock and other domestic animals. Among various other features, nematodes are most diverse group of animals in terms of their size and life-span. Some of the diseases caused by parasitic nematodes in humans have become priority of global health. Large scale sequencing of the genomes from parasitic nematodes itself highlights their impact on human survival. In order to better understand the situation, in-depth knowledge about the parasite, its impact on socio-economic conditions is must. Data on these accounts help in deciding the course of action, area to focus and making informed policy decisions. New approaches have undoubtedly helped human kind with various treatment option and better socio-economic status. There are several important parasitic nematodes with reference to human and veterinary importance. This review covers the impact of the common parasitic nematode infecting humans as well as animals and highlights the current issues and prospects associated with the management of these nematodes.

KEY WORDS: ASCARIS; IMPACT; NEMATODES; PARASITES; WHO.

INTRODUCTION

The word 'helminth' is a general term, which is often used to convey one or the other form of parasitic infections. In academic and research world, it is a broad term encompassing all known flatworms and roundworms. Helminths are metazoan animals with multi-cellular arrangement and a body which is like a tube within tube. Outer tube is a tough cuticular skin and the inner tube contains all the body parts including digestive and reproductive systems. These animals exhibit bilateral symmetry, triploblastic in terms of muscular arrangement and important pseudocoelomatic creatures of the nature (Okwa, 2020). While majority of helminths are free-living in aquatic and terrestrial environment, few are parasites in human and plants. It is the parasitic forms which have received much attention due to the diseases they cause in both humans as well as in plants (Elton, 2020, Combes, 2020).

Helminths are very special compared to other parasites in nature (Rapin & Harris, 2018). Their development is quite slow compared to other infectious pathogens. Diseases caused by helminths have slow onset but are chronic in nature (Mutapi et al., 2017). Although mostly go as asymptomatic, helminths infection cause severe economic damage worldwide and are associated with

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high level of morbidity and mortality (Krolewiecki & Nutman, 2019). All human parasitic nematodes have similar life cycle with certain notable differences (Ancell & Pires-daSilva, 2017, Jex, et al., 2019). They demonstrate a well developed sexual dimorphism. Females of the parasitic nematode produces large number of eggs that after hatching pass through four larval stages and turn into an adult (Chaudhuri et al., 2011). Understanding the life-cycle of animal parasitic nematode is essential to identify the vulnerable stages which can be targeted for its management. Common route of transmission adopted by nematode parasite includes faecal-oral transmission, transdermal transmission, vector-borne transmission and predator-prey transmission (Furtado et al., 2020).

Infection by parasitic nematodes is a common problem throughout the world. Their enormous distribution and infections in human population can be understood by a fact that in year 1946, it was estimated that a population of 2.2 billion at that time had 2.3 billion nematode infections. Each human being was infected by more than one nematode (Becker et al., 2018). Their impact on the lives of human and animals is very drastic and frightening. Nematode infections are a cause of serious problem in the developing world where intestinal infections are the most frequent ones. Common intestinal nematodes from the developing world are *Ascaris lumbricoides, Trichuris trichiura* and *Strongyloides stercoralis* (Table-1). Important nematodes of veterinary importance are *Ostertagia ostertagi, Cooperia oncophora, Teladorsagia circumcincta, Haemonchus contortus, Dictyocaulus viviparous*. Details of each of these nematodes are listed (Table-2).

From human perspective, these three nematodes account for three-quarter of all infections (Freeman et al., 2019). Global atlas on nematode infection is compiled based on the findings of several research groups. Throughout the world, more than half of the population is affected by nematode infections. Even in the presence of modern medical aids, incidences of nematode infections are continuously increasing mostly from the developing world (Van Den Hoogen et al., 2019). A number of factors are responsible for this increase, which includes lack of awareness about proper sanitation and health related issues. Treatment of the nematode infection depends mostly on chemical based medicines (Werkman et al., 2020). Recently, the progresses in research have led to discoveries of plant based antihelmintic treatments (Liu et al., 2020, Zajícková et al., 2020).

In order to make informed policy decisions and plan better management strategies, detailed and meaningful data is required. This review presents the insight and highlights the impact of the nematode infection on human and animals. Progress in the field of parasitic nematodes has not seen much pace compared to other fields. Major reason for this slow growth had been the biology of these animals. These animals live deep inside their host, are bio-trophic in nature, have long life-cycles, are difficult to culture in laboratory outside their host etc. Through this review an attempt has been made to summarize the important parasitic helminths which are responsible for significant morbidity in both humans as well as animals. In order to summarize the details, we have looked in to various publication, looked in to metadata presented, searched important search engines and presented the updated details.

Reason Behind The Ignorance: There are around 342 species of nematode that infect human beings (Laurimaa et al., 2016). Nematode infections have increased with increasing human population globally (Sorobetea et al., 2018). Published data suggests that there are significant numbers of infections reported worldwide. Out of the 3500 million infections worldwide, there are 450 million individual who require serious medical attention. As per recorded data, more than 125000 deaths occur every year due to nematode infections, particularly by *Ancyclostoma* (Coulibaly et al., 2019). The reason behind ignorance of nematode infection is primarily due to their asymptomatic and non fatal nature compared to the infections cause by protozoan parasites especially malaria, which receives so much public attention and huge research funding (Rückerl, 2020). Most common symptoms associated with parasitic nematodes infection in humans include abdominal pain, diarrhoea, malnutrition, and anaemia (Tamarozzi et al., 2019). In certain case of *Trichuris* infection, cognitive function is impaired to some extent, due to secondary infections by opportunistic pathogens etc. Details about the mechanism of infection, adverse effect of infection and the economical impact due to these infections can be gained from several excellent reviews (Jourdan et al., 2018, Wright et al., 2018, Ramlal et al., 2019 Norman et al., 2020).

Problem in Management of Nematode Infections: As mentioned earlier that good level of personal hygiene, proper sanitation and health-related education is a must for creating awareness against these infections. Based on the published reports, only personal hygiene helps in reducing the rising cases of nematode infections throughout the globe (World Health Organization, 2018). There are various challenges associated with management of nematode infections. Since the problem of nematode infection is a global problem, its management becomes more complex because of varying level of environmental, social and economic factors across different countries. Scientists have pointed out that it is next to impossible to get our world free from nematode infections, but certainly we should be able to manage it. In order to control or limit the infections caused by helminths, focus must be on reducing contact based transmission of parasites as this strategy will help in reducing the risk of spreading further infections (World Health Organization, 2019).

Control Methods: The treatment and control of animal parasitic nematode infection is primarily dependent on anthelmintic drugs. Benzimidazoles group of medicines like albendazole and mebendazole, imidazothiazoles group of medicines such as levamisole and pyrantel are common chemical anthelmintic drugs recommended by

various agencies (Enejo & Suleiman, 2017; Gandasegui et al., 2020). Thiabendazole, which is structurally related to albendazole and mebendazole, is used widely for the treatment of several nematodes of cattle, horses, and sheep (Legarda-Ceballos et al., 2016). Dithiazanine is another nematode anthelmintic used in veterinary medicine; it is effective against heartworms and threadworms. Diethylcarbamazine is the drug of choice for treatment of filariasis caused by a parasitic nematode, *Wuchereria bancrofti* throughout the globe (McCarthy & Moore, 2015, Misra-Bhattacharya & Shahab, 2018).

Though, a polytherapy treatment that includes ivermectin with diethylcarbamazine or albendazole is more effective than either drug alone. Macrocyclic lactones group of medicines are an important class of anthelmintics for the control of nematode parasites and some ectoparasites in livestock, companion animals and in humans (Prichard & Geary 2019). Similarly, pyrantel pamoate is effective against *Ancyclostoma*. As a part of integrated pest management, scientists are looking beyond the reliance only on chemical based anthelmintics for treatment of parasitic nematode infections. Certain plant metabolites have been also evaluated for controlling nematode diseases of humans (Athanasiadou et al., 2007, Punetha et al., 2020). Use of plant based products for controlling livestock nematodes has also been tried. Plant based products offer alternative methods of controlling animal parasitic nematodes (Behera & Bhatnagar, 2018, Garcia-Bustos et al., 2019).

Table 1. List of important nematodes causing significant infection in humans

S.No	Name of the parasite	Common Name	Clinical symptoms	Transmission	Distribution	Number of people infected worldwide	References
1.	*Ascaris lumbricoides*	Roundworm	Abdominal pain, diarrhoea, malnutrition	Ingestion of eggs	Worldwide	807-1,121 Million	(Shah and Shahidullah, 2018)
2.	*Ancylostoma duodenale*	Hookworm	Cough, dyspnea and Hemoptysis	Contaminated soil	Worldwide	576-740 Million	(Giramkar, 2020)
3.	*Trichuris trichiura*	Whipworms	Abdominal pain, unexpected weight loss	Contaminated soil and food	Worldwide	604-795 Million	(Else. et al., 2020)
4.	*Onchocerca volvulus*	River Blindness worm	Skin and lymph node inflammation	Repeated bites by black flies	Sub-Saharan Africa	187 Million	(Otabil. et al., 2019)
5.	*Wuchereria bancrofti*	Filarial worm	Lymphedema,	Through the bite of an infectious mosquito	Africa and India	893 Million	(Zulch. et al., 2020)
6.	*Brugia malayi*	Filarial worm	Ulceration of the affected lymph node	Mosquito vector	South-east Asia	120 Million	(Liu et al, 2018)
7.	*Dracunculus medinensis*	Guinea worm	Nausea, vomiting, Blisters.	By drinking unfiltered water	Remote areas of Africa	3.5 Million	(Robert L, 2019)
8.	*Enterobius vermicularis*	Pin worm	Perianal pruritus	Ingestion of Infectious eggs	Worldwide	1.0 Billion	(Fan et al., 2019)

Socio-Ecomonic Impact of Helminths Infection: Significant morbidity and mortality takes places due to infections by helminths (Feasey et al., 2010, Gadoth, 2019). Many regions of the world, especially the developing world are facing severe problem due to the infections caused by helminths (De Rycker et al., 2018). Unhygienic living conditions and non-availability of safe drinking water is directly linked to the development and proliferation of these diseases. In essence, parasitic diseases caused by helminths are considered to be the diseases of poor and exhibit significant socio-economic impact on the society (Lindahl & Grace, 2015). The

severity of the impact can be felt through the disease burden both in human as well as in livestock. Developing countries are particularly are at the risk of this uninvited socio-economic burden due to large population, poor hygienic conditions and lack of awareness (Gizaw et al, 2020).

Significant progress has been made by agencies such as United Nations Development programme and World Health Organization in assessing the socio-economic impact of these tropical diseases (Bangert et al., 2017). With the aid from these agencies, global disease burden can be minimized either through eradication or controlling specific diseases. All such project will surely involve the cost effectiveness or cost benefit. However, the information gathered through these special programmes is helping in decision making in respect to treatment and control. Results obtained through survey studies and clinical approaches are used at national level for making key decisions about the socio-economic consequences of diseases caused by helminths and their control.

Table 2. List of important nematodes from veterinary perspective

S.No.	Name of the parasite	Host	Distribution	References
1.	*Ostertagia ostertagi*	Gastrointestinal nematodes (GINs) of grazing cattle	Worldwide	(Singh B. et al., 2019)
2.	*Cooperia oncophora*	Gastrointestinal nematodes (GINs) of grazing cattle	Worldwide	(Candy et al., 2018)
3.	*Teladorsagia circumcincta*	Small ruminants such as sheep	Worldwide	(Stear. et al., 2019)
4.	*Haemonchus contortus*	Attached to the abomasum of ruminants (sheep, goats and cattle)	Worldwide	(Brik. et al., 2019)
5.	*Dictyocaulus viviparous*	In the bronchial tree of horses, sheep, goats, deer, and cattle	Worldwide	(Claerebout & Geldhof 2020)

More research on prevalence, its distribution and infection mechanism is required in order to reduce the burden of parasitic diseases and to plan initiatives for its prevention and control (Redekop et al., 2017). Helminths cause significant economic losses worldwide. Due to helminths infection in cattle, overall loss has been estimated to be $ 50.67 per animal per year, which in terms of percentage, is 17.94% annually (Rashid et al., 2019). Data on economic losses due to helminths infection in humans is not available directly but the seriousness can be inferred from the fact that approximately 1.0 billion people are infected by these helminths annually (Gordon et al., 2017, Sherman, 2018).

CONCLUSION

Nematode cause considerable problems in both human as well as in domestic and veterinary animals. These infections not only cause significant deleterious effect on the life of their hosts but also cause huge monetary loss. Though impact of the diseases could be dramatically reduced by improved sanitation for humans and pasture control in domestic animals, such methods are insufficient to eradicate these parasites. In the absence of vaccines, use of chemical based compounds is the sole method to ease disease symptoms, control infection and reduce transmission. Irrespective of having WHO recommended global standard anthelmintics drugs available for treatment of nematode infections, cases of nematode infection are on the rise. The intensive and indiscriminate use of these drugs has led to widespread resistance to all current anthelmintics.

Continuous search for new anthelmintics agents and identification of new drug targets is required to overcome or prevent the issue of drug resistance. Many plant based naturally occurring compounds have been reported to possess anti-nematode potential. There is also need for well trained and skilled professionals who are capable of integrating and implementing new technologies into their countries. As the problem is global, several health agencies of various countries need to work in collaborated and coordinated manner in order to combat the disease. There is an urgent need for viable, safe and sustainable control strategies that requires an integrated approach incorporating environmental management, and includes a combination drug therapy so as to minimize the chances of parasite adaptation.

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