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Plant Extracts: A Potential Tool for Controlling Animal Parasitic Nematodes

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1. Introduction

Many plants play a crucial role in maintaining animal and human life in a natural balance with a tendency to establish an environmental armory among the different biosphere inhabitants. During evolution of living organisms in the biosphere biological interactions with other organisms are established and they affect each other in many ways. Different types of relationships are involved among organisms including parasitism. Heritable strategies of biological adaptation are developed by living organisms to overcome adverse environmental conditions. Plants have developed biochemical mechanisms to defend themselves from biological antagonists that act as their natural enemies (Ryan and Jagendorft, 1995). This principle has led scientists to search for bio-active compounds produced by plants against pathogens (Sheludko, 2010). Since long a number of plants and their metabolites are evaluated against diseases of importance not only in public health (Shah et al., 1987); but also in animal and agricultural production (Githiori et al., 2006). In the present chapter, the importance of using plant extracts as an alternative method of control of animal parasitic nematodes is reviewed from a broad perspective.

2. Use of plants as a source of phyto-medicines

Ancestral cultures worldwide developed, over many centuries, several cures and remedies from plants and plant extracts against many diseases affecting human populations and a traditional medicinal system based on empiric knowledge was established and was improved through time (Hillier and Jewel, 1983). Some devastating infectious diseases *ie.,* malaria, responsible for deaths of thousands of people can be overcome with traditional herbal anti-malarian drugs obtained from South America, Africa and Asia *ie.,* Cinchona (*Cinchona sp.),* Qing hao (*Artemisa annua*), Changshan (*Dichroa febrifuga*), Neem (*Azadirachta indica*), *Cryptolepsis sanguinolenta*) and other plants (Willcox et al., 2005). Researchers around the world have scientifically explored the real effect of many plants used as medicines

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whose uses are not validated by rigorous scientific experimentation. Many plants are being screened for anti-parasitic effects on animals; since animal behaviour reveals self-medication when animals select and ingest some specific plants (Cousing and Huffman, 2002; Huffman, 2003). In Hawaii, Rodriguez et al (1985) reported an interesting work based on a peculiar behavior of primates in the Hawaiian jungle. Researchers noticed that troops of chimpanzees ate some plants that they had previously selected and which they fed their progeny. Researchers suspected that such plants could contain alkaloids with hallucinogenic effects and probably could act as stimulants as alkaloid drugs do. After in-depth studies of those plants researchers found a group of bio-active compounds which can treat bacterial, fungal and nematodal infections. Hence, the researchers concluded that primate behavior responded to a mechanism of self/cure using selected plants as phyto-medicines (Sumer and Plutkin, 2000). During the last decades the study of medical principles from plants has gained considerable interest and a number of natural bio-active compounds from plant extracts are currently commercially available to cure many diseases.

3. Parasites of veterinary importance

Livestock industry worldwide is severely affected by a number of infectious diseases caused by different kinds of parasites. The present chapter focuses on the use of plant extracts against the group of internal parasites and particularly to helminths known as Gastrointestimal Parasitic Nematodes (GIN); considered to be one of the most economically important group of parasites affecting the animal productivity around the world (Poglaven and Battelli, 2006; Abdel-Ghaffar et al., 2011). The most frequent GIN of ruminants in many countries around the world are: *Haemonchus contortus, Mecistocirrus digitatus, Trichostrongylus colubriformis, T. axei, Bunostomum trigonocephalum, Cooperia curticei, Teladorsagia circumcincta, Nematodirus spp, Trichuris ovis, T. globulosa, Strongyloides papillosus, Gaigeria pachyscelis, Chabertia ovina* and *Oesophagostomum columbianum* (Torres Acosta et al., 2005; Valcárcel Sancho et al., 2009). In this group of parasites the nematodes have a remarkable status as the main pathogens causing severe damage to their hosts. *Haemonchus contortus* and other genera/species of nematodes belonging to the group of trichostrongylids are of major concern because its blood-sucking feeding habits cause anemia that can be so severe resulting in the death of the animals (Macedo Barragán et al., 2009). This group of parasites is widespread in almost all tropical and sub-tropical countries and is considered responsible for deteriorating animal health and productivity.

4. Chemotherapy as the unique method of control

The most common method used to control ruminant helminthiasis is the use of chemical compounds commercially available as anti-helmintic drugs that are regularly administered to animals for deworming; the method is considered simple, safe and cheap (Jackson, 2009). There are several disadvantages in the use of such products such as their adverse effect against beneficial microorganisms in soil once they are eliminated with the feces (Martínez and Cruz, 2009). On the other hand, some anthelmintic compounds can remain as contaminants in animal products destined for human consumption *ie.,* meat, milk, etc. (FAO, 2002). One of the main concerns in the use of anthelmintic drugs for controlling

ruminant parasites is the development of anthelmintic resistance in the parasites that decreases the efficacy of the drugs (Sutherland and Leathwick, 2011; Torres-Acosta et al., 2011) and threatens economical sustainability of sheep production (Sargison, 2011). The anthelmintic resistance can reach enormous proportions when parasites develop mutations in their genome against different groups of anthelmintic drugs. Such phenomenon is known as "Multiple anthelmintic resistance" and it is a real threat to the inefficacy of commercially available anthelmintics (Taylor et al., 2009; Saeed et al., 2010). Such situation has motivated workers around the world to look for alternatives to control these parasites. Searching for plant bio-active compounds with medical properties against parasites has gained great interest in order to at least partially replace the use of chemical drugs.

5. Exploring the anti-parasitic properties of plants

A wide range of plants and their products around the world are being explored to look for their possible anthelmintic effects on cestodes and trematodes (Abdel-Ghaffar et al., 2011), and against nematodes (Datsu Kalip et al., 2011). Due to the important economic impact of gastrointestinal parasitic nematodes in the livestock industry around the world, most of the research on plant extracts are being focused on searching bioactive compounds from plants against this important group of parasites. Traditionally, some plants around the world are well known as anti-parasitic plants because they contain substances with anthelmintic effects against parasitic nematodes affecting agricultural crops (Krueger et al., 2009) or animal parasitic nematodes (Galicia Aguilar et al., 2008; López Aroche et al., 2008; De Jesús Gabino et al., 2010). Perhaps, the most known cases of plants with nematicidal properties around the world are garlic (*Allium sativum*) (Iqbal et al., 2001; Qadir et al., 2010) Marigold (*Tagetes erecta*) Krueger et al., 2009; Bhardwaj et al., (2010) and the goosefoot or Epazote (*Chenopodium abrosioides*) (Yadav et al., 2007; Eguale and Mirutse, 2009). Another example is the South African plant *Curtisia dentata* commonly used for ages by rural communities as a remedy to cure a number of diseases caused by bacteria and fungi in either human being or animals (Shai et al., 2008; Dold and Cocks, 2001) and against animal parasitic nematodes (Shai et al., 2009). Nevertheless, every year, the list of new plants with nematocidal *in vitro* and *in vivo* properties against animal parasites is growing as new natural alternatives for replacing (at least partially) the use of chemical drugs (Tables 1 and 2).

Some forage have been evaluated searching for potential bio-active compounds against sheep and goat parasitic nematodes with variable results. However studies must be intensified; since some individual limitations in application have been noticed; *ie.*, toxicity, metabolic disorders and inappropriate applications can cause severe damage and even the death of treated animals (Rahmann and Seip, 2008). Other plants are being investigated as bio-active forages in the control of *Haemonchus contortus* in lambs with good/moderate results. For instance Wormwood (*Artemisia absinthium*) which was offered to lambs for voluntary intake, parasitic burden was reduced almost in 50%. Additionally, faecal egg excretion expressed on a dry matter basis was also reduced by 73% in animals fed with the selected plant (Valderrábano et al., 2010). On the other hand, other plant/plant extracts *ie., Melia azedarach* (Chinaberrry tree, Indian Lilac) have shown promising results in trials that confirmed not only a very good anthelmintic efficiency, but also no side-effects (Akhtar and Riffat, 1984). Some plant extract have shown an extraordinary bio-activity against sheep

Table 1. In vitro nematocidal effect of different plant extracts against nematodes of livestock importance

Plant	Extract	Target nematode	Anti-nematode Effi
Adhatoda vasica	aqueous and ethanolic extracts	*H. contortus, O. circumcincta, Trichostrongylus spp,*	84-89% in vitro hatch inhibition
Adhatoda vasica	aqueous and ethanolic extracts	*S. papillosus, Oe.columbianum*	81-85% larval develo inhibition
Tagetes erecta	Acetonic extract	*Haemonchus contortus* (L4)	99.7% lethal activity
Castela tortuosa	Hexanic extract	*Haemonchus contortus* (L4)	95.8% lethal activity
Prosopis laevigata	Hexanic extract	*Haemonchus contortus* (L3)	81% maximum morta
Bursera copalifera	Acetonic extract	*Haemonchus contortus* (L3)	66% máximum morta
Acacia pennatula, Lysiloma latisiliquum, Piscidia piscipula y *Leucaena leucocephala*	Acetone/water extracts	*H. contortus*	Variable range of lar migration inhibition different *H. contortus*
Salvadora persica	Aqueous extract	Strongyline nematodes	99.9% anthelmintic a
Terminalia avicenoides	Aqueous extract	Strongyline nematodes	100 %anthelmintic ac

Table 2. In vivo nematocidal effect of different plant extracts against nematodes of livestock importance

Plant	Extract	Target nematode	Animal specie	% efficacy
Artemisia absinthium	Crude Ethanolic extract	*Haemonchus contortus*	sheep	Faecal egg count redu (FECR) of 90.46%
Artemisia absinthium	Crude aqueous extract	*Haemonchus contortus*	sheep	Faecal egg count redu (FECR) of 80.49%
Prosopis laevigata	n-hexanic extract	*Haemonchus contortus*	Jirds	Parasitic burden was r in 42.5%
Parkia biglobosa	Aqueous extract	*Haemonchus*, *Trichostrongylus*, *Oesophagostomum* and *Bunostomum* species	Bovine	Produced a high hatch inhibition
Piper tuberculatum	Oil extract	*Strongyloides venezuelensis*	*Rattus norvegicus*	No in vivo anthelmint

parasitic nematodes; *ie.,* supplementing sheep with a *Fumaria parviflora* ethanol extract eliminated fecal eggs and caused 72 and 88% mortality of adult *Haemonchus contortus* and *Trichostrongylus colubriformis*, respectively (Hördegen et al., 2003). These are only a few examples of candidate plant extracts to be used in the control of parasites in sheep and goat farming. Rochfort et al (2008) from Australia published a very complete and extraordinary review about bioactive plants and their impact on animal health and productivity. On the other hand, Diehl et al (2004) published the results of a very interesting research project evaluating eighty six plant extracts from Ivory Coast flora and finding that fifty percent of the evaluated plants had nematocidal activity against *Haemonchus contortus* larvae. Such results showed evidence about the important nematocidal activity of plants from Ivory Coast as potential ethnobotanical tools of control against ruminant parasitic nematodes (Diehl et al., 2004). Some recent reports of nematocidal activity of plant extracts against ruminant parasites in different countries are described as follows: In Pakistan, *Adhatoda vasica* both aqueous and ethanolic extracts exhibit an *in vitro* ovicidal and larvicidal activity ranging between 81-89% against diverse genera/specie of gastrointestinal parasitic nematodes of sheep (Al-Shaibani et al., 2008). In Burkina, Faso, two medicinal plants *Anogeissus leiocarpus* and *Daniellia oliveri* were analyzed to identify their anthelmintic effect against nematodes of sheep abomasum. *A. leiocarpus* and *D. oliveri* showed a maximum lethal activity, between 80 and 100%, respectively, against adult *Haemonchus contortus* (Aldama et al., 2009; Kaboure et al., 2009). Many countries have developed important screening of plant extracts with anthelmintic properties from their native flora with an enormous potential for the control of animal parasitic nematodes with encouraging results. Some countries *i.e*. Brazil, India, South Africa, China and others possesses an extraordinary richness in their medicinal flora and they have currently developed an important industry from plant extracts ably supported by science. Some researchers stand out for their important contributions in this regard: Githiori et al (2006) at the International Livestock Research Institute in Nairobi, Kenya; Iqbal et al (2001) and his group or researchers from the Department of Veterinary Parasitology, University of Agriculture, Faisalabad, Pakistan have developed a solid package of information about a big list of native plants with encouraging results in the control of sheep parasites (Iqbal et al., 2001; 2004; Bachaya et al., 2009).

6. Condensed tannin-rich plants

A number of research works have focused on the anthelmintic effect of tannin rich plants against GIN. This group of bio-active compounds present in selected plant material are being obtained from all over the world, from temperate areas (Athanasiadou et al., 2004; Hoste et al., 2006) as well as from tropical tannin rich fodders (Alonso-Diaz et al., 2010). Interdisciplinary groups of researchers (Hoste et al., 2006; Alonso Díaz et al., 2008; Calderón-Quintal et al., 2010; Martínez-Ortíz-de-Montellano et al., 2010) have developed important research studies on tannin-rich plants in the control of *H. contortus* and other important gastrointestinal nematodes. Most scientific works focused on identifying the bio-active compounds produced by nematocidal plants have reported the presence of different molecules including catechins, condensed tannins, flavonoids and steroids (Oliveira et al., 2009) and polyphenolics (Lorimer et al., 1996); as well as bio-active enzymes such as cystein protease and secondary metabolites such as alkaloids, glycosides and tannins

(Athanasiadou and Kvriazakis, 2004). Further in-depth studies need to be undertaken since even though anti-parasitic properties are being demonstrated, negative effects such as reduction in food intake by animals have been identified and this should be considered before establishing their use as an alternative method of control (Githiori et al., 2006).

In recent studies, researchers are reaching beyond the general knowledge about lethal *in vitro* activity of plants and bio-active compounds derived from selected plants against the most important nematode parasites of ruminants. New efforts are being carried out to find practical applications of plants or plant products in the control of ruminant parasitic nematodes; including ways and means of overcoming limitations in applications to animals (Rahmann and Seipa, 2007). Recently in Laos, reduction in appearance of nematode eggs on goat feces with the Cassava foliage supplement has been demonstrated (Phengvichith and Preston, 2011).

7. Conclusions

The use of chemical anthelmintic drugs for controlling animal parasitic nematodes is rapidly loosing popularity due to a number of disadvantages. Anthelmintic resistance in the parasites is spreading and the inefficacy of chemical anti-parasitic compounds is threatening animal health. New plants with medicinal properties against parasites of ruminants are being investigated around the world with promising results. In the near future natural products obtained from plants extracts seems that likely will become a viable alternative of control of parasitizes of veterinary importance. When plant/plant extracts are being selected for use as anti-parasitic drugs in sheep particular attention should be given to the fact that the bio-active compound could be found in stems, roots, leaves, flowers, fruits or even in the entire plant. This means that obtaining plant extracts is a laborious and complex process. Also, the mode of extraction and the solvent used can determine the success in isolating the expected bioactive compounds; since a wide variety of compounds can be hidden into the structural parts of the plants and the only way they could be isolated is through exploring the use of a range of organic solvents. On the other hand, a rigorous effort to identify possible side effects due to the administration of plant extracts should be established before carrying *in vivo* assays. It is remarkablly important to consider that using plant/plant extracts as a unique method of control is insufficient to control itself the parasitosis in the animals. So, an alternated or combined method with other methods of control should be considered as an integrated method which would lead to reduce the use of chemical anthelmintic drugs.

8. Acknowledgments

Authors whish to express their gratitude to Dr. Felipe Torres Acosta (Autonomous University of Yucatan, Mexico) for his valuable comments on this chapter.

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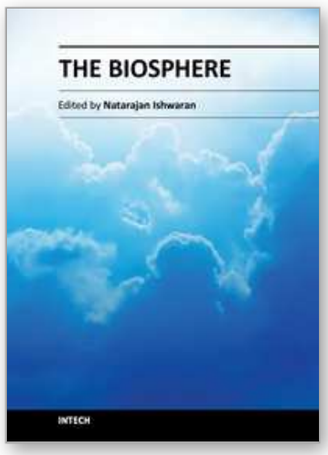

The Biosphere

Edited by Dr. Natarajan Ishwaran

ISBN 978-953-51-0292-2
Hard cover, 302 pages
Publisher InTech
Published online 14, March, 2012
Published in print edition March, 2012

In this book entitled "The Biosphere", researchers from all regions of the world report on their findings to explore the origins, evolution, ecosystems and resource utilization patterns of the biosphere. Some describe the complexities and challenges that humanity faces in its efforts to experiment and establish a new partnership with nature in places designated as biosphere reserves by UNESCO under its Man and the Biosphere (MAB) Programme. At the dawn of the 21st century humanity is ever more aware and conscious of the adverse consequences that it has brought upon global climate change and biodiversity loss. We are at a critical moment of reflection and action to work out a new compact with the biosphere that sustains our own wellbeing and that of our planetary companions. This book is a modest attempt to enrich and enable that special moment and its march ahead in human history.

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