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Review Article

An Overview of the Plants Reported for Having Acaricidal and Anthelmintic Properties

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Abstract

Geo-climatic and socio-economic conditions provide a favourable environment for parasitic population of livestock in Pakistan. Hard ticks (Ixodidae) and gastrointestinal nematodes pose most serious threats to livestock industry. Stockholders rely on synthetic drugs to control these parasites. Emergence of drug resistance in these parasites, however, has limited a sole approach and advocating integrating approach for the efficient control of the parasites. Medicinal plants (MP) comprised a large body in integrated control measures. This article devoted to the current findings on efficacy of the MP against ticks and gastrointestinal nematodes, particularly focusing on *Rhipicephalus microplus* (Tropical cattle tick) and *Haemonchus contortus* (Stomach worm of sheep). As far as this review is concerned, Fabaceae (18.42%), Asteraceae (5.33%), and Apiaceae (4.45%) are noted as top three families in the literature. *Azadirachta indica* and *Butea monosperma* were most reported as acrcicial and anthelmintic, respectively followed in order by *Ocimumba silicum, Melinis minutiflora* as acricidial and *Caesalpinia crista*, *Azadirachta indica* as anthelmintic. Inclination of researchers to evaluate MP as anthelmintics (37.72%) is higher ($p > 5$) as compare to acaridicals (62.28%). The overwhelming emphasis on MP in literature corroboration their alternative and/or integrative role in controlling parasites (Against ticks and helminthes). Nevertheless, immersion of cutting edge technologies in evaluation process of MP is recommended. © 2017 Friends Science Publishers

Keywords: Anthelmintics; *Rhipicephalus microplus*; *Haemonchus controtus*; Gastrointestinal nematodes; Plants

Introduction

Livestock play a crucial role in human food supplies and economy of Pakistan (Anonymous, 2014-2015). Parasitism is one of the most important constraints in optimum productivity of animals. Production losses due to parasitism may vary from one parasite to the other. In tick infestation, for example, losses may be due to loss of blood (Gabr, 2012), tick paralysis (Chand *et al*., 2016), transmission of different diseases (Duvallet and Boireau, 2015; Kmieciak *et al*., 2016), treatment costs (Gomes *et al*., 2016), lowered milk yield etc. Likewise, gastrointestinal nematodes (GINs) may interfere with food intake and absorption and thus adversely affect animal productivity (Geurden *et al*., 2015; Ravinet *et al*., 2016).

Globally, ticks are incriminated for devastating diseases (Godfrey and Randolph, 2011; Opara *et al*., 2016; Demessie and Derso, 2015). In Tanzania, economic losses due to ticks and tick-borne diseases resulting from production/mortality losses, treatment and control costs associated with tick-borne diseases have been estimated at US$ 364 million. Risk of ticks and ticks transmitted diseases increased upto 95.8% in Europe (Kunze, 2010). In China, 98.75% cases of mortality in livestock were found associated with ticks and tick borne disease (Zheng *et al*., 2012; Chen *et al.*, 2014). Overall losses in Pakistan are 16.35% and at farm and per animal 21776 and 3763 Pak rupees, respectively (Ashfaq *et al*., 2015). *Hyalomma anatolicum* and *Rhiphicephalus sanguineus* are the most abundant tick species reported from large and small ruminants in Pakistan. They are involved in transmitting Babesia (Including B. divergens, B. bovis and B. bovis), Theileria (T. parva and T. annulata) and Anaplasma (A. centrale and A. marginale) (Ahmed *et al*., 2012; Jabbar *et al*., 2015; Zahid *et al*., 2016).

Surveys indicate that upto 95% of sheep and goats in the tropics are infected with helminthes and that *Haemonchus* and *Trichostrongylus* are the main genera involved (Khan *et al*., 2010a; Bansal *et al*., 2015; Dalal *et al*., 2015). Mortality rates in herd may exceed 40% while weight losses of 12 kg/year/animal may occur (Borji *et al*., 2012; Roeber *et al*., 2013). However, insidious productivity losses through reduced feed intake and decreased efficiency in feed utilization, associated with subclinical or chronic conditions, carcass quality, milk production and immune response are often the largest economic losses (Katoch *et*

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al., 2012; Singh *et al*., 2014; Scala *et al*., 2015). Some of the workers have monetized the production losses due to helminth infections in animals in different parts of the world. For example, US$ 64.12 million in Kenya due to fascioliasis and haemonchosis (Voigt *et al*., 2016), 13.39, 40, 14 and 25 million (Pakistani Rupees) due to reduction in milk yield, weight gain, mortalities and treatment expenditures, respectively (Qamar *et al*., 2011) in Pakistan. Year and area wise prevalence of *H. contortus* in sheep was recorded in Pakistan as 9.43% Swat, 14% in District Bahawalpur, 50-76% in Rawalpindi, 21.7% to 68% in Faisalabad, 20% to 24.9% in Muzaffar Garh district (Ayaz, 2015), 44.17% in Toba Tek Singh (Khan *et al*., 2010b), 77.7% in Multan (Tasawar *et al*., 2010), 25.26% in D.G. Khan (Lashari *et al*., 2015).

Control of Parasitism

In general, the control of ticks and GIN predominantly depends upon chemotherapy, even after the advancements in genetically, immunological and biotechnological methods (Sorge *et al*., 2015; McTier *et al*., 2016; Verma and Singh, 2016). Globally, however, use of synthetic drugs for animal health and production is facing challenges due to a variety of factors. For example, because of their high costs (Mondal *et al*., 2013), general toxicity (Patel *et al*., 2013), drug residual problems in milk and meat (Elmanama and Albayoumi, 2016; Tochi *et al*., 2016) and development of drug resistance in ticks (Abbas *et al*., 2014; Coles and Dryden, 2014; Heath and Levot, 2015; Kumar and Partap, 2015; Muyobela *et al*., 2015; Vudriko *et al*., 2016) and GIN (Playford *et al*., 2014; Alonso-Diaz *et al*., 2008; Borges *et al*., 2015; Geurden *et al*., 2015; Muniz-Lagunes *et al*., 2015; Ramos *et al*., 2016). In addition, quality of antiparasitic drugs particularly in developing countries has led to attention of the stakeholders to find alternatives, may be as a part of drug resistance management programs (Zaman *et al*., 2011; Zaman *et al*., 2012; Ghosh *et al*., 2015a; Kumar *et al*., 2016). Prospects of using plants as alternates to synthetic antiparasitic drugs have been discussed in the following paragraphs.

Plants as Anti-parasitics

Plants and/or their products have been used for treatment of different diseases for centuries. There is an extended relationship among the coexistence of herbal remedies, parasites and humans (Matsabisa *et al*., 2013). It is as old as history of man itself. The plant kingdom is a vast storehouse of chemical substances manufactured and used by plants as defenses against insects, bacteria, fungi and viruses (Rattan, 2010; Mithöfer and Boland, 2012). Plants are known to produce a range of secondary metabolites such as terpenoids, alkaloids, polyacetylenes, flavanoids and unusual amino acids and sugars (Chen *et al*., 2011; Savithramma *et al*., 2011; Hussain *et al*., 2012), for their defense from attack by pests. Plants constitute major part of the traditional veterinary practices termed as “ethnoveterinary medicine (EVM)” (Upadhyay *et al*., 2011; Asadbeigi *et al*., 2014). These plants may also posses’ biological activity against significant parasites of veterinary standpoint, which could effectively be used to control ecto- and endo-parasites post-scientific validation. The efficacy of plant extracts/products against endo- and ecto-parasites of animals have been reported with variable success (Chen *et al*., 2011; Maphosa and Masika, 2012; Martinez-Ortiz-de-Montellano *et al*., 2013; Mbaya and Ogwiji, 2014; Silva *et al*., 2014; Kumarasinghe *et al*., 2016). Most frequently used plants are sown either by the farmers or found self-grown, in the fields. These can also be obtained from the herbal/grocery stores easily. Farmers can use the wild herbs by uprooting from fields. In Pakistan, farmers believe that control of a parasite of a particular region is provided by nature in the form the indigenous plants of the area (Personal Communication).

In tropical countries, common-and-economic availability of plants render them to be most viable options as alternates of synthetic antiparasitics drugs (Chander *et al*., 2013; Neergheen-Bhujun, 2013; Tamboli *et al*., 2015). As far as it can be ascertained, 66 (n=66) and 318 (n=318) publications are available in literature based on plants as acaricides and anthlemintics, respectively (http://www.ncbi.nlm.nih.gov/pubmed/?term=anthelmintic+based+on+plants; endnote X5; http://www.ncbi.nlm.nih.gov/pubmed/?term=anthelmintic+based+on+plants; endnote X5). Literature on the use of plants as acaricides and anthelmintics has been selectively reviewed as under:

Plants Used as Acaricidals

For the last ten years (2005-2015), 58% increase in citation of MP against ticks per year has been noticed (Bhardwaj *et al*., 2012; Benelli *et al*., 2016). However, in Pakistan, only handful number of MP have been used against *R. microplus* (Zaman *et al*., 2011; Sindhu *et al*., 2012; Nawaz *et al*., 2015). Across the globe, it has been investigating extensively (Chen *et al*., 2011; dos Santos *et al*., 2013; Nyahangare *et al*., 2015; Fouche *et al*., 2016a). Apart from *R. mircroplus*, other significant arthopods of veterinary standpoint have also been assessed as far as MP are concerned. For example, against pediculosis.

Some plants reported for their anti-tick activity have been selectively reviewed and listed in Table 1.

Tests Used for Evaluation of Anti-tick Activity

***In vitro*:** MP have been mostly evaluated through in vitro bioassays for preliminary screening. Three types of tests have been adopted i.e., Larval immersion test, larval packet test adult immersion test and syringe test.

Table 1: Plants used against cattle ticks

PLANT	PART USED	TICK	FAMILY	REFERENCE (S)
Acanthus ebracteatus	Leaf	*R. microplus*	Acanthaceae	Chungsamarnyart *et al*., 1988
Acorus calamus	Rhizome	*R. microplus*	Acoraceae	Pathak *et al*., 2004
Aegle marmelos	Leaf	*R. microplus*	Rutaceae	Kamaraj *et al.*, 2011
Ageratum houstonianum	Leaf	*R. lunulatus*; *R. microplus*	Asteraceae	Pamo *et al*., 2005; Parveen *et al*., 2014
Ageratum conyzoides	Whole plant	*R. microplus*	Asteraceae	Kumar *et al.*, 2016
Allium sativum	Bulb	*R. pulchellus*; *R. microplus*	Amaryllidaceae	Shyma *et al.*, 2014
Annona squamosal	Seed	*R. microplus*	Annonaceae	Ilham *et al.*, 2014
Artemisia absinthium	Oil	*R. microplus*	Asteraceae	Thakur *et al*., 2007; Godara *et al*., 2014
Azadirachta indica	Oil	*R. microplus*	Meliaceae	Thakur *et al*., 2007
	Bark	*R. microplus*		Pathak *et al*., 2004; Maharaj *et al*.,2005
	Leaf	*R. microplus*		Handule *et al*., 2002; Pathak *et al*., 2004, Nawaz et al., 2015
	Seed	*R. microplus*		Chagas *et al.*, 2016
Citrus Spp.	Peel oil	*R. microplus*	Rutaceae	Ghosh *et al*., 2015
Cymbopogon winterianus	Essential oil	*R. microplus*	Poaceae	de Mello *et al.*, 2014
Dahlstedtia pentaphylla	Root	*R. microplus*	Fabaceae	Pereira and Famadas, 2006
Datura stramonium	Leaves	*R. microplus*	Solanaceae	Ghosh *et al*.., 2015
Drimys brasiliensis	Essential oil of stem/leaf	*R. microplus, R. sanguineus*	Winteraceae	Ribeiro *et al*., 2007, Ribeiro *et al*., 2008
Gynandropsis gynandra	Essential oil	*R. appendiculatus*	Cleomaceae	Malonza, 1992; Lwande *et al*., 1999
Hypericum polyanthemum	Aerial part	*R. microplus*	Hypericaceae	Ribeiro *et al*.,2007
Lavandula officinalis	Essential oil	*R. annulatus*	Lamiaceae	Abdel-Shafy and Soliman, 2004
Lippia gracilis	Essential oil	*R. microplus*	Verbenaceae	Cruz *et al.*, 2013
Luffa acutangula	Not Reported	*R. microplus*	Cucurbitaceae	Chungsamarnyart *et al.*, 1988
Margaritaria discoidea	Not Reported	*R. appendiculatus,*	Phyllanthaceae	Kaaya *et al.*, 1995
Marjorana hortensis	Not Reported	*R. annulatus*	Lamiaceae	Abdel-Shafy and Soliman, 2004
Matricaria chamomile	Flower	*R. annulatus, R. microplus*	Asteraceae	Pirali-Kheirabadi and Razzaghi-Abyaneh, 2007
Melia azedarach	Leaf	*R. microplus*	Meliaceae	Matias *et al.*, 2003
	Fruit	*R. microplus*		Sousa *et al.*, 2011
Melinis minutiflora	Whole plant	*R. appendiculatus*; *R. microplus*	Poaceae	Muro *et al.* 2004, Fernandez-Ruvalcaba *et al.* 2004
Mentha piperita	Whole plant	*R. annulatus; R. microplus*	Lamiaceae	Abdel-Shafy and Soliman, 2004; Chagas *et al.* 2016
Neoglaziovia variegata	Leaves and aerial part	*R. microplus*	Bromeliaceae	Dantas *et al.*, 2015
Nicotiana tabacum	Leaf	*R. haemaphysaloides; R. microplus*	Solanaceae	Choudhary *et al.*, 2004; Maroyi, 2012, Zaman *et al.*, 2012, Farooq *et al.*, 2008
Ocimum basilicum	Leaves	*R. annulatus; R. microplus*	Lamiaceae	Abdel-Shafy and Soliman, 2004; Martinez-Velazquez *et al.*, 2011, Veeramani *et al.*, 2014
Ocimum suave	Leaf	*R. appendiculatus*	Lamiaceae	Mwangi *et al.*, 1995, Magona *et al.*, 2011
Pimentadioica dioica	Bark and leaf; Seed	*R. microplus*	Myrtaceae	Brown *et al.*, 1998; Martinez-Velazquez *et al.*, 2011
Pongamia pinnata	Essential Oil, Seed	*R. microplus; R. pulchellus*	Fabaceae	Thakur *et al.*, 2007; Handule *et al.*, 2002
Cleome hirta	Essential oil	*R. appendiculatus*	Capparaceae	Ndungu *et al.*, 1999
Sapindus saponaria	Stem	*R. microplus*	Sapindaceae	Fernandes *et al*. 2005
Semecarpus anacardium	Leaves	*R. microplus*	Anacardiaceae	Ghosh *et al*. 2015
Stemona collinsiae	Rhizomes; Root	*R. microplus*	Stemonaceae	Chungsamarnyart *et al.*, 1988; Kongkiatpaiboon *et al.*, 2014
Stylosanthes hamata	Aerial parts	*R. microplus*	Fabaceae	Fernandez-Ruvalcaba *et al.*, 1999, Muro *et al.*, 2003
Stylosanthes humilis	Aerial parts	*R. microplus*	Fabaceae	Fernandez-Ruvalcaba *et al.*, 1999, Muro *et al.*, 2003
Syzygiumaromaticum	Essential oil	*R. microplus*	Myrtaceae	de Mello *et al.*, 2014
Tamarindus indicus	Seeds; Fruits	*R. annulatus; R. microplus*	Fabaceae	Guneidy *et al.*, 2014
Vitex agnus-castus	Seed	*R. sanguineus*	Lamiaceae	Mehlhorn *et al.*, 2005

R = Rhipicephalus

Larval immersion test (LIT): Being laborious test, (needs six weeks of generating results) this test is not recommended by FAO however, many workers adopted this test (Kumar and Partap, 2015) may be due to its ease of conduction. The fully blood engorged female's ticks immersed in the various concentrations of the candidate drugs for 2-4 mins. All the ticks weigh together pre-immersion (WPI). The efficacy of the drug measures through the mortality rate (up to 14 days post-immersion), weigh of the eggs laid by the ticks, reproductive index (RI) calculated by egg weight divided by WPI and oviposition inhibition (OI) (RI control-RI treated/RI Control)×100). A major advantage of LIT is that it does not need any specific solvent, rendering it more suitable for plants extracts.

Larval packet test (LPT): This is a time-efficient test and fully supported by FAO and have been adapted by many workers (Chagas *et al*., 2016; Vudriko *et al*., 2016). During this test, the larvae were inserted into drug impregnated filter paper for 24 hrs at certain temperature (27-29 C) and relative humidity (80-85%). Assessment of mortality/motility of the larvae criterion express the efficacy of the drugs. Trichloroethylene use as solvent in LPT. Plant extracts are insoluble in this solvent thus only a limited number of scientists adapted it to evaluate MP efficacy. However, some workers modified LPT and used acetone in lieu of trichloroethylene. Also used ethanol and methanol to dissolve plant extract in addition to acetone. Only condition of the solvent is that it should not cause mortality of tick's larvae more than 5% in control group.

Adult Immersion Test (AIT): This is another FAO recommended bioassays. However, it is a laborious test (at least 4 weeks) and involves strict precautionary measures, difficult to arrange (e.g., only healthy ticks, weigh of the group of ticks and egg mass should be proportionate etc.)

thus only a few workers adapted this test (Ghosh *et al*., 2015b). In this test, the group of the ticks (at least group of 10 ticks n=10 in each group) remains in contact with the drug for 30 S and efficiency is measured through egg laying capacity of the female ticks. Egg laying capability asses by number of tick laying eggs dividing by number of untreated ticks laying eggs. Efficacy of MP can easily be assessed through AIT, because it does not require any specific solvent. It was noticed that most of workers used AIT along with LIT.

Syringe test (ST): Most recently introduced test and basically modification in larval immersion. Main difference is use of 14 days old larvae, which are to be exposed to candidate drugs for 30 sec. Special syringes, with cutting nozzle end and withdrawn plunger (2 mL), are prepared. After placing eggs in the cutting end of the syringe, it closes tightly with organza fabric until eggs hatch out and fourteen days' pass. The larvae immerse for 30 sec and the syringe subject to fume hood for drying (1 h). The main criterion of efficacy evaluation is causing death of the larvae or their incapability to walk (Sindu *et al*., 2012). Until now, this test has been used only to evaluate efficacy of MP (Nawaz *et al*., 2015).

***In vivo* ear bag method:** A bag fabricates with Muslin cloth with a certain size (13 17 cm) is used to facilitate attachment of seed ticks (freshly hatched larvae) on the animals. After the successful attachment of the seed ticks, the candidate drugs are applied topically. The evaluation criterion is drop off the tick due to action of the drug (Zaman *et al*., 2012). This is equally applicable for synthetic drugs as well as for MP (Ghosh *et al*., 2011, 2013, 2015).

Plants Used as Anthelmintics

Worldwide, a number of medicinal plants have been used to treat gastro-intestinal helminthiasis (Orr, 2015; Habibi *et al*., 2016; Nosal *et al*., 2016). An account of the plants used as anthelmintics is given in Table 2. In Pakistan, more than 50 indigenous species of MP have been evaluated against *H. contortus in vitro* and/or *in vivo* for the last ten years (2005-2015). *In vitro* and *in vivo*, *Calotropis procera*, *Swertia chirata*, *Butea monosperma*, *Trachyspermum ammi*, *Chenopodium album* and *Caesalpinia crista*, *Terminalia arjuna*, *Adhatoda vasica*, *Azadirachta indica*, *Convolvulus arvensis*, *Nicotiana tabacum*, *Saussuria lappa*, *Terminalia chebula* (Sindhu *et al*., 2014) and *Berberis lycium* have been recorded highly efficacious, more than 80 and 40%, respectively. *Zingiber officinale* assessed *in vivo* and showed highly efficacy 60%. *In vitro*, *Artemisia brevifolia*, *Artemisia maritime* (Khan *et al*., 2015), *Capparis decidua*, *Salsola foetida*, *Suaeda fruticosa*, *Haloxylon salicornicum*, *and Haloxylon recurvum* (Raza *et al*., 2016) have been reported. Some workers have been evaluated combined effect of some of those plants which already been recorded as anthelmintics.

Tests Used for Evaluation of Anthelmintic Activity

***In vitro*:** *H. contortus* has been widely used as experimental worm to evaluate in vitro anthelmintic activity of different MP (Ademola and Eloff, 2010; Carvalho *et al*., 2012; Acharya *et al*., 2014; Akther *et al*., 2015; Klongsiriwet *et al*., 2015). Some workers have also used *Trichostrongylus colubriformis*, *Dictycaulus viviparous*, hookworms, tapeworms and/or *Ascaris lumbricoides* for the evaluation of *in vitro* anthelmintic activity of different plant materials.

During the last decade, *in vitro*, egg hatch test (Aremu *et al*., 2010; Ademola *et al*., 2011; Adoum, 2016; Fouche *et al*., 2016b; Meenakshisundaram *et al*., 2016); Alonso-Díaz *et al*., 2011; Kamaraj *et al*., 2011; Al-Rofaai *et al*., 2013; Ademola *et al*., 2010; Carvalho *et al*., 2012) and adult motility tests (Ferreira *et al*., 2016; Raza *et al*., 2016; Uppala *et al*., 2016) have been introduced and used for evaluation of anthelmintic efficacy of plants/plant products.

Egg hatch test: Fresh eggs (unhatched eggs) are incubated for 72 h with various concentrations of candidate drugs. Inhibition of hatching is main criterion for efficacy of the candidate drugs. Tap water has been used for serial dilutions of the candidate drugs in earlier research however, found inappropriate as ions naturally present in the water effect on egg hatching. Thus, protocol of this test has been revolutionized by using distilled ionized water as solvent of drugs in lieu of tap water. It was further noticed that eggs obtained from female *H. contortus* could be of various stage of embryonation so copro-purified eggs generate more reliable results.

Larval migration inhibition assay: Yong larvae, less than two weeks, are keep with various concentrations of candidate drugs in dark. Post 24 h incubation, they contents are subjected to sieve and allowed to migrate for 24 h. The sieve containing un-migrated larvae washed careful in separate wells. Success of the test measured by inability of larvae to migrate through sieve due to paralysis. However, this test has only been adopted limitedly due to coiled larvae of *H. contortus* increase time requirement and can bias the test results.

Larval development assay: This test measure shifts of first larval stages of Trichostronglids to infective stage (Third larval stage) and takes 6-7 days to be completed (Demeler *et al*., 2010).

Adult motility assay: The basic theology of this test is similar as described in larval migration inhibition test. Adult worms collected from freshly slaughtered animals are subjected to various drug concentrations for 6 h. Observance of motility for 30 min in PBS post-treatment is main criteria.

***In vivo*:** Fecal egg count reduction test and post-mortem examination are only two tests available to perform *in vivo* anthelmintic assessment trials, former test is adopted most due to ease of conduction and inexpensive. MP workers also adopted this test (Lone *et al*., 2012, 2013; Coasta *et al*., 2016).

Table 2: Plants used as anthelmintics

PLANT	PART USED	HELMINTH (S)	FAMILY	REFERENCE (S)
Acacia albida	Seed	Mixed infection of GIN	Fabaceae	Nwude & Ibrahim, 1980
Acacia gaumeri	Leaves	*Haemonchus controtus*	Fabaceae	Alonso-Diaz *et al.*, 2011
Acacia pennatula	Leaves	*Haemonchus controtus*	Fabaceae	Alonso-Diaz *et al.*, 2008
Acacia nilotica	Fruit	Mixed infection of GIN	Fabaceae	Bachaya *et al.*, 2009
Adhatoda vasica	Root and leaf	Mixed infection of GIN	Acanthaceae	Al-Shaibani *et al.*, 2009b; Somnath *et al.*, 2015
Agrimonia eupatoria	Not Reported	Mixed infection of GIN	Rosaceae	Farnsworth *et al.*, 1985
Albizia anthelmintica	Bark	Mixed infection of GIN	Mimosaeae	Minja, 1989
	Root	*Haemonchus contortus*		Githiori *et al.* 2003; Gathuma *et al.* 2004; Grade *et al.* 2008
Allium sativum	Bulb	*Haemonchus contortus*; Mixed infection of GIN	Amaryllidaceae	Iqbal *et al.*, 2001, Ahmed *et al.*, 2014
Aloe ferox	Leaves	*Haemonchus contortus*	Asphodelaceae	Maphosa *et al.*, 2010
Amomum aromaticum	Seeds	*Haemonchus contortus*	Zingiberaceae	Kaushik *et al.*, 1981
Anacardium occidentale	Essential oil	*Haemonchus contortus*	Anacardiaceae	Ademola & Eloff, 2011
Ananas comosus	Not reported	*Haemonchus contortus*	Bromeliaceae	Ahmed *et al.*, 2014
Areca catechu	Nut	*Haemonchus contortus*	Arecaceae	Barbieri *et al.*, 2014
Artemisia brevifolia	Whole plant	*Haemonchus contortus*	Compositae	Iqbal *et al.*, 2004; Irum *et al.*, 2015
Artemisia herbaalba	Shoot	*Haemonchus contortus*	Asteraceae	Idris *et al.*, 1982; Seddiek *et al.*, 2011
Azadirachta indica	Leaf	Mixed infection of GIN; *Haemonchus contortus*	Meliaceae	Radhakrishnan *et al.*, 2007; Jamra *et al.*, 2015
	Seed	*Haemonchus contortus*		Hördegen *et al*., 2006, Costa et al., 2008
				Costa *et al.*, 2008
		Mixed infection of GIN		Iqbal *et al.*, 2010
	Cake and Leaf	Mixed infection of GIN		Gowda, 1997; Mostofa *et al.*, 1996
Boswellia dalzielii	Bark	Mixed infection of GIN	Burseraceae	Nwude and Ibrahim,1980
Butea Spp.	Various parts	*Haemonchus contortus;* Mixed infection of GIN	Fabaceae	Singh *et al.*, 2015; Lateef *et al.*, 2006a; Iqbal *et al.*, 2006
Caesalpinia crista	Seed	Mixed infection of GIN; *Haemonchus contortus*	Fabaceae	Jabbar *et al.*, 2007; Bhardwaj *et al.*, 2015
	Fruit	Mixed infection of GIN		
Calliandra calothyrsus	Legume	*Haemonchus contortus*	Fabaceae	Cresswell, 2007; Florence & Mbida, 2011,
Calotropis procera	Flower	Mixed infection of GIN	Apocynaceae	Iqbal *et al.*, 2005a
	Latex	*Haemonchus contortus*		Murti *et al.*, 2015; Cavalcante *et al.*, 2016
Carum copticum	Seed	Mixed infection of GIN	Apiaceae	Lateef *et al.*, 2006a; Boskabady *et al.*, 2014
Carissa edulis	Root	Mixed infection of GIN	Apocynaceae	Mishra *et al.*, 2012
Cassia spectabilis	Root	*Haemonchus contortus*	Fabaceae	Morais-Costa *et al.*, 2015
Chenopodium album	Whole plant	Mixed infection of GIN	Amaranthaceae	Jabbar *et al.*, 2007 ; Nayak *et al.*, 2010
Chenopodium ambrosioides	Leaf	Haemonchus contortus; Mixed infection of GIN	Amaranthaceae	Eguale & Giday, 2009; Salifou *et al.*, 2013
	Essential oil	*Haemonchus contortus*; Mixed infection of GIN		Ketzis *et al.*, 2002; Macdonald *et al.*, 2004
Chrysophyllum cainito	Stem	*Haemonchus contortus*	Sapotaceae	Fernandez *et al.*, 2013
Coriandrum sativum	Seeds	*Haemonchus contortus*	Apiaceae	Eguale *et al.*, 2007
Cucurbita máxima	Seeds	Mixed infection of GIN	Cucurbitaceae	Ayaz *et al.*, 2015
Cucurbita Mexicana	Seeds	*Haemonchus contortus*	Cucurbitaceae	Ayaz *et al.*, 2015
Cymbopogon nardus	Whole plant	Haemonchus contortus	Poaceae	Jeyathilakan *et al.*, 2010
Dalbergia latifolia	Bark and Stem	*Haemonchus contortus*	Fabaceae	Daryatmo *et al.*, 2010
Elephantorrhiza elephantina	Roots	*Haemonchus contortus*	Fabaceae	Maphosa *et al.*, 2010
Embelia ribes	Seed	*Haemonchus contortus*	Myrsinaceae	Swarnkar *et al.*, 2009
Erythrina senegalensis	Bark	*Haemonchus contortus*	Fabaceae	Williams *et al.*, 2016
Eucalyptus globulus	Leaves	*Haemonchus contortus*	Myrtaceae	
Fagara heitzii	Leaves	Mix infection of GIN	Rutaceae	Hounzangbe *et al.*, 2005
Ferula foetidissima	Not Reported	*Haemonchus contortus*	Apiaceae	Pustovoi, 1968
Ficus religiosa	Bark	*Haemonchus contortus*	Urticaceae	Iqbal *et al.*, 2001
Fumaria parviflora	Whole plant	Mixed infection of GIN	Fumariaceae	Al-Shaibani *et al.*, 2009a
Hagenia abyssainica	Fruit	Mixed infection of GIN	Rosaceae	ITDG and IIRR, 1996
Heracleum sosnowskyi	Not Reported	Mixed infection of GIN	Apiaceae	Gadzhiev and Eminove, 1986a, 1986b
Lagenaria siceraria	Seed	Haemonchus contortus; *Pheretima posthuma* (Earthworm)	Cucurbitaceae	Khan *et al.*, 2010
Lawsonia inermis	Flower and seed	*Eicinia fetida* (Red californian earthworm)	Lythraceae	Wadekar *et al.*, 2016
Leonotis leonurus	Leaves	Mix infection of GIN	Lamiaceae	Maphosa *et al.*, 2010
Leucaena leucocephala	Leaves	*Haemonchus contortus*	Fabaceae	Alonso-Diaz *et al.*, 2008
Lippia sidoides	Essential oil	Mix infection of GIN	Verbenaceae	Camurça-Vasconcelos *et al.*, 2008
Lysiloma latisiliquum	Leaves	*Haemonchus contortus*; Mix infection of GIN	Fabaceae	Alonso-Diaz *et al.*, 2008; Brunet *et al.*, 2008
Mallotus philippinensis	Fruit, powder	Mix infection of GIN	Euphorbiaceae	Gangwar *et al.*, 2013
Melia azedarach	Fruit	Mixed infection of GIN	Meliaceae	Cala *et al.*, 2012
Momordica charantia	Fruits	*Haemonchus contortus*	Cucurbitaceae	Rashid *et al.*, 2016
Moringa oleífera	Root	Mixed infection of GIN	Moringaceae	Salles *et al.*, 2014
Musa paradisiaca	Leaves	Mix infection of GIN	Musaceae	Hussain *et al.*, 2010, 2011, Marie-Magdeleine *et al.*, 2014
Myracrodr uonurundeuva	Leaves	*Haemonchus contortus*	Anarcadiaceae	de Oliveira *et al.*, 2011
Myrsine Africana	Leaves	*Haemonchus contortus*	Myrsinaceae	Getachew *et al.*, 2012
Nicotiana tabacum	Leaves	*Haemonchus contortus*	Solanaceae	Iqbal *et al.*, 2006, Worku *et al.*, 2009, Epperson, 2013, Hamad *et al.*, 2013
Nigella sativa	Seed	*Haemonchus contortus*	Ranunculaceae	Burke *et al.*, 2009, Shalaby *et al.*, 2012
Piscidia piscipula	Leaves	*Haemonchus contortus*	Fabaceae	Alonso-Diaz *et al.*, 2008
Rapanea melanophloeos	Fruits	*Haemonchus contortus*	Myrsinaceae	
Scutia myrtina	Roots	*Haemonchus contortus*	Rhamnaceae	Ayers *et al.*, 2007
Semecarpus anacardium	Nut	Mixed infection of GIN; *Haemonchus contortus*	Anacardiaceae	Pal *et al.*, 2008; Tandon *et al.*, 2011
Spigelia anthelmia	Aerial parts	*Haemonchus contortus*	Loganiaceae	Ademola *et al.*, 2007
Thymus capitatus	Aerial parts	Mixed infection of GIN	Lamiaceae	Elandalousi *et al.*, 2013
Trachyspermum ammi	Seed	*Haemonchus contortus*	Apiaceae	Jabbar *et al.*, 2006b
Trianthema portulacastrum	Whole plant	Mix infection of GIN; *Haemonchus contortus*	Aizoaceae	Hussain *et al.*, 2011, de Mello *et al.*, 2013
Vernonia anthelmintica	Seed	*Haemonchus contortus*	Asteraceae	
Zingiber officinale	Rhizome	Mixed infection of GIN	Zingiberaceae	Peachey *et al.*, 2015
Ziziphus nummularia	Bark	Mixed infection of GIN	Rhamnaceae	Bachaya *et al.*, 2009

GIN = gastrointestinal nematodes

Only those plants were selected which showed significant reduction (35%, 5>) in fecal egg counts as compare to control

Table 3: Plant Families (%) studies as acaricidal and anthelmintics

Sr. No.	Family	Acaridcidal	Anthelmintic
1.	Acanthaceae	0.41	1.41
2.	Aizoaceae	0	1.41
3.	Amaryllidaceae	0.41	2.87
4.	Anacardiaceae	0.41	4.23
5.	Apiaceae	0	7.04
6.	Apocynaceae	0	2.87
7.	Arecaceae	0	1.41
8.	Asphodelaceae	0	1.41
9.	Asteraceae	1.29	2.84
10.	Bromeliaceae	0.43	0.71
11.	Burseraceae	0	0.71
12.	Compositae	0	0.71
13.	Cucurbitaceae	0.43	2.84
14.	Ebenaceae	0	0.71
15.	Euphorbiaceae	0	0.71
16.	Fabaceae	2.15	16
17.	Fumariaceae	0	0.71
18.	Lamiaceae	2.58	2.28
19.	Loganiaceae	0	0.71
20.	Lythraceae	0	0.71
21.	Meliaceae	0.86	2.28
22.	Mimosaeae	0	0.71
23.	Moringaceae	0	0.71
24.	Musaceae	0	0.71
25.	Myrsinaceae	0	2.13
26.	Myrtaceae	0.86	1.42
27.	Poaceae	0.86	0.71
28.	Ranunculaceae	0	0.71
29.	Rhamnaceae	0	1.42
30.	Rosaceae	0	1.42
31.	Sapotaceae	0	0.71
32.	Solanaceae	0.86	0.71
33.	Verbenaceae	0.43	0.71
34.	Woodsiaceae	0	0.71
35.	Zingiberaceae	0	1.42

Fecal egg count reduction test (FECRT): Efficacy is measured through reduction of number of eggs in fecal samples post-treatment with candidate drug. Fecundity of *H. contortus* is high. So, it yields best reliable results in case of *H. contortus* due to strong positive correlation between magnitudes of infection with number of eggs in feces.

Conclusion

MP have been widely used in world to control parasitic load in livestock. 43 and 71 MP, belong to 35 families have been reported as acricidial and anthelmintic, respectively. Overwhelming studies on MP (~65 publications for last 10 years) of Pakistani scientists depicting the significant role of this source for stakeholders and researchers. Some paucities are, albeit, still to be addressed. For instance, generally it is not reported from where the plants have been cultivated/grow up/taken, basis of selection of MP, *in vitro* and *in vivo* bioassays and methods of extraction. These factors soundly relate with bio-actions of the MP and be considered importantly.

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