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Small Ruminant Research 38 (2000) 99–107

Small Ruminant Research

www.elsevier.com/locate/smallrumres

Review

Anthelmintic activity of medicinal plants with particular reference to their use in animals in the Indo–Pakistan subcontinent

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Received 10 May 1999; accepted 5 April 2000

Abstract

Helminthiasis is one of the most important group of parasitic diseases in Indo-Pakistan subcontinent resulting in heavy production losses in livestock. A wide variety of anthelmintics is used for the treatment of helminths in animals. However, the development of resistance in helminths against commonly used anthelmintics have always been a challenge faced by the animal health care professionals. Therefore, exploitation of anthelmintic potential of plants indigenous to Indo-Pak subcontinent is an area of research interest. This paper reviews the use of some indigenous plants as anthelmintics in animals.

Keywords: Helminthiasis; Medicinal plants; Indo–Pakistan subcontinent

1. Introduction

Helminthiasis is one of the most important animal diseases worldwide, inflicting heavy production losses in grazing animals. The disease is especially prevalent in developing countries (Dhar et al., 1982) in association with poor management practices and inadequate control measures. An integrated approach is required for the effective control of helminths which includes strategic and tactical use of anthelmintics and careful management of grazing lands, including control of stocking rates and appropriate rotation strategies. Vaccinations may also play a role, as in the case of lungworms. However, problems have emerged with the use of anthelmintics, notably the development of resistance in helminths (Waller and Prichard, 1985) to various anthelmintic compounds and classes, as well as chemical residue and toxicity problems (Kaemmerer and Butenkotter, 1973). In addition, recognition of the antigenic complexity of parasites has slowed vaccine development. For these various reasons, interest in the screening of medicinal plants for their anthelmintic activity remains of great scientific interest despite extensive use of synthetic chemicals in modern clinical practices all over the world. The plant kingdom is known to provide a rich source of botanical anthelmintics, antibacterials and insecticides (Satyavati et al., 1976; Lewis and Elvin-Lewis, 1977). A number of medicinal plants have been used to treat parasitic infections in man and animals (Nadkarni, 1954; Chopra et al., 1956; Said, 1969). In this paper, studies on anthelmintic evaluation of some plants indigenous to India and Pakistan have been reviewed.

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0921-4488/00/$ – see front matter
PII: S0921-4488(00)00163-2

2. Traditional use of medicinal plants

Plants have been used from ancient times to cure diseases of man and animals. This system of therapy is commonly referred as 'unani, folk, eastern, or indigenous' medicine (Nadkarni, 1954). There are a many plants[1] which have been reported in the literature for their medicinal importance. For example, *Caesalpinia crista* (Leguminosae;[2] karanjwa[3]), *Melia azedarach* (Meliaceae; bakain), *Saussurea lappa* (Compositae; qust-e-shireen), *Morringa oleifera* (Moringaceae; sohanjna), *Trachelospermum jasminoides* (Apocynaceae; zard chambeli), *Butea frondosa* (Leguminosae; Dhak) have been quite commonly used (Nadkarni, 1954). The medicinal properties ascribed to these plants include *inter alia* anthelmintic, antiperiodic, antipyretic, febrifugal, antiphlegmatic, and antiflatulant effects. In addition, these plants have also been used to cure nervous problems, skin diseases, cough, rheumatism, chronic fever, eczema and dyspepsia (Anonymous, 1956; Chopra et al., 1956; Ikram and Hussain, 1978; Awan, 1981). The fruit of *Mallotus phillippinensis* (Euphorbiacea; kamala) has been used as an anthelmintic, cathartic, aphrodisiac, lithotropic and styptic. It has also been used in external applications for the control of parasitic infections of the skin, as an antiseptic for ears and systemically for urinary disorders (Chopra et al., 1956; Ikram and Hussain, 1978; Satyavati et al., 1987). The British Pharmaceutical Codex (1934) and the British Veterinary Codex (1953) cite kamala as having anticestodal properties for man and dog (Akhtar and Ahmad, 1992).

Seeds of *Butea superba* (Leguminosae; palaslata) are extensively used as sedative and anthelmintic in the indigenous system of medicine (Charka, 1948; Chopra et al., 1958). The powdered seeds and various extracts of the plant *Peganum harmala* (Rutaceae; harmal) have been used as narcotic, analgesic, antispasmodic in colic and as a remedy against tapeworm infection in man and animals (Chopra et al., 1956; Said, 1969). *Vernonia anthelmintica* (Compositae; kali-zeeri), *Embellia ribes* (Myrsinaceae; babrung), *Psoralea corylifolia* (Leguminosae; babchi) and *Punica granatum* (Punicacae; anar) have been reported to possess anthelmintic, laxative, expectorant, diuretic and tonic properties (Nadkarni, 1954; Chopra et al., 1956; Srivastava et al., 1967; Said, 1969; Ikram and Hussain, 1978; Awan, 1981; Akhtar and Riffat, 1985a). Various parts of *Lagenaria siceraria* (Cucurbitacae; kaddoo) have been used for different ailments. For example, the pulp of its fruit is used to treat cough, as an adjunct to purgatives, as an antidote to certain poisons, and for relief from scorpion stings (Nadkarni, 1954; Ahmad, 1965). Decoction of its leaves is used to treat jaundice (Chopra et al., 1956; Said, 1969) and its seeds to treat tapeworm infections in children (Awan, 1981). *Fumaria parviflora* (Fumariaceae; pit-papra or shahterah) is traditionally used as an antidiabetic, diaphoretic, diuretic, anthelmintic (Nadkarni, 1954; Chopra et al., 1956). *Nigella sativa* (Ranunculaceae; kalonji) is used on empirical grounds as an anthelmintic, stimulant and diuretic (Nadkarni, 1954; Said, 1969). The roots of *Morus alba* (Urticaceae; toot or tut) are considered as an anthelmintic and vermifuge, whereas root bark and stem bark are reported to act as vermifuge and purgative.

3. Methodologies for scientific evaluation of anthelmintic activity

Many of the in vitro investigations on anthelmintic activity of plants, their oils, or extracts have been based on their toxic effects on the earthworm, *Pheritima posthuma* (Gaind and Budhiraja, 1967; Ali and Mehta, 1970; Kokate and Varma, 1971; Dixit and Varma, 1975; Banerjee and Nigam, 1978; Girgune et al., 1978; Agarwal et al., 1979; Girgune et al., 1979; Mishra et al., 1979; Mehta et al., 1981; Dengre, 1982; Garg and Kasera, 1982a, b; Nanda et al., 1987; Siddiqui and Garg, 1990; Garg and Siddiqui, 1992). Most of the substances which are toxic to earthworms produce a primary irritation or agitation that results in the withdrawal of the worm from the neighborhood of the poison. By virtue of this effect, anthelmintics doubtless often cause expulsion of the parasite when the concentration does not rise sufficiently high to kill

[1] The taxonomic family and local names of each plant are given in parenthesis following its Latin name. When the information is not given, it indicates that the authors could not find the information or the same information already has been given earlier in the text.

[2] Taxonomic family.

[3] Local name.

the worm (Sollmann, 1918). Some workers have also used hookworms, tapeworms and/or *Ascaris lumbricoides* for the evaluation of in vitro anthelmintic activity of different plant materials (Dubey and Gupta, 1968; Kalesaraj, 1974, 1975; Dixit and Varma, 1975; Banerjee and Nigam, 1978; Girgune et al., 1978; Agarwal et al., 1979; Girgune et al., 1979; Mishra et al., 1979; Sharma et al., 1979; Shrivastava, 1979; D'Cruz et al., 1980; Mehta et al., 1981; Dengre, 1982; Garg and Kasera, 1982a, b; Kakrani and Kalyani, 1984; Kalyani et al., 1989; Siddiqui and Garg, 1990; Nakhare and Garg, 1991; Garg and Siddiqui, 1992; Garg and Jain, 1992). In vivo trials have also been conducted for the evaluation of anthelmintic activity of various substances of plant origin. These included expulsion of worms from their hosts (Kalesaraj and Kurup, 1968; Lawrence, 1990; Philips, 1990; Pradhan et al., 1992; Asuzu and Onu, 1994; Desta, 1995) or reduction in the number of eggs per gram of feces (EPG) passed by the infected hosts compared with commercial anthelmintic treated animals (Akhtar, 1988).

4. Anthelmintic activity

Indigenous system of medicine reports a number of plants for their anthelmintic efficacy. However, rigorous scientific evaluations comparing their efficacy to commercial anthelmintics are limited. Alkaloid hydrochlorides extracted from seeds of *Butea frondosa* @ 0.1–2.0 mg/ml proved 100% lethal to earthworms within 24 h indicating their anthelmintic activity (Kalesaraj and Kurup, 1962). Garg and Atal (1963) reported remarkable vermicidal activity of Calotropain {proteolytic enzyme isolated from the latex of *Calotropis procera* (Asclepiadaceae; ak)} and Bromelain (an enzyme obtained as a by-product from pineapple industry) against *Oesophagostomum columbianum* and *Bunostomum trigonocephalum* of sheep origin compared to phenothiazine.

The aqueous extracts of *Chebulic myrobalans* (local name harar), *Belleric myrobalans* (local name bahera) and *Emblic myrobalans* (local name ambla), separately and as a mixture in equal parts (locally known as triphala) were each found to possess good anthelmintic activity. However, triphala had greater activity indicating a synergistic action of the three constituents combined (Gaind et al., 1964). In vitro anthelmintic activity of the aqueous and alcoholic extracts of *Ananas sativus* (Bromeliaceaea; anannas), *Embellia ribes*, *Macuna prurita* (Leguminosae; kouchkari) and *Melia azedarach* has significant activity against *Taenia canina* and *Paramphistomum cervi; Macuna prurita* was especially active against trematodes (Neogi et al., 1964). The anthelmintic property of the aqueous extract of the seeds of *Carica papaya* (Carbicaeceae; ppiya) against *Ascaris lumbricoides* and *Ascaridia galli* has been evaluated (Dhar et al., 1965).

A steam volatile oil from the petroleum ether of *Withania coagulans* (Solanaceae; khumazare) has been found to possess lethal effect on earthworms (Gaind and Budhiraja, 1967). The aqueous, etheral and alcoholic extracts of *Cucurbita mexicana* (Cucurbitaceae; kuddu) seeds have exhibited good anthelmintic activity against *Moniezia expansa*, *Fasciolopsis buski*, *Ascaris lumbricoides Hymenolepis diminuta*. The order of potency of the extracts in vitro was aqueous, alcoholic and etheral, in decreasing order (Shrivastava and Singh, 1967). The root bark of *Alangium larmarckii* (Alangiaceae; akola) has exhibited good efficacy against the hookworms of dogs and poultry ascarids (Dubey and Gupta, 1968).

Anacardic acid isolated from the oil of nuts of *Semecarpus anacardium* (Anacardiaceae; bhinladar) and its sodium salt have been found to be potent anthelmintic agents (Chattopadhyaya and Khare, 1969). The essential oil of *Piper betle* (Piperaceae; pan) has revealed anthelmintic effect on earthworms in vitro (Ali and Mehta, 1970). The anthelmintic activity of essential oil of *P. betle* against tapeworms has been found to be superior to that of piperazine phosphate, and the activity against hookworms has been reported greater than that of hexylresorcinol (Garg and Jain, 1992). Anthelmintic studies of the essential oils of *Cymbopogon nardus* (Graminaceae; ganjni), *C. citratus* (Graminaceae; khawi) and *Zanthoxylum alatum* (Rutaceae; tejbal) have revealed that the oil of *C. nardus* has very good effect against earthworms while the oils of *C. citratus* and *Z. alatum* have moderate activity (Kokate and Varma, 1971).

Sharma et al. (1971) have reported significant in vitro effect of extracts of *Cucurbita pepo* (Cucurbitaceaea; halwa kuddu), *Calotropis gigantea* (Asclepiadaceae; ak) , *Juglans regia* (Juglandaceae; akhrot), *Momordica charantia* (Cucurbitaceae; karela), *Musa*

paradisaca (Musaceae; kela) and *Scindapsus officinalis* (Araceae; gajapipal) on the motility of mature *Haemonchus contortus* of goat origin. The anthelmintic activity of alcoholic extracts of stem of *Helleborus niger* (Ranunculaceae; katurchini), rhizomes of *Zingiber officinale* (Zingiberaceae; adrak), seeds of *Carum copticum* (Umbelliferae; ajwain-e-khurasani), *Agati gratifola* (Leguminosae; agasti) and *Mangifera indica* (Anacardiaceae; aam) against human *Ascaris lumbricoides* is appreciable (Kalesaraj, 1974). Rhizomes of *Zingiber zerumbet* (Zingiberaceae) showed good in vitro anthelmintic activity against human *Ascaris lumbricoides*, while the alcoholic extract of the bark of *Albizzia lebbek* (Leguminosae; siris), the bulb of *Allium sativum* (Litiaceae; lahsan), rhizomes of *Alpinia calcarata* (Zingiberaceae; toroni), rind of *Citrus acida* (Rutaceae) rind of *Citrus aromatica* (Rutaceae; santara), rind of *Citrus medica* (Rutaceae; kaghzi nibu), rhizomes of *Cucuruma aromatica* (Zingiberaceae; banhalud), rind of *Punica granatum* showed moderate in vitro activity (Kalesaraj, 1975).

The oils of the rhizomes of *Hedychium coronarium* (Zingiberaceae) and *H. spicatum* (Zingiberaceae; karchura) possess better anthelmintic activity than piperazine phosphate against earthworms and tapeworms though the activity against hookworms and nodular worms does not compare favorably with that of hexylresorcinol (Dixit and Varma, 1975). The in vitro anthelmintic activity of *Caraca papaya*, *Sapindus trifoliatum* (Sapindaceae; raitha), *Butea frondosa* and *Momordica charantia* has been reported (Lal et al., 1976) against *Ascaridia galli* worms in fowl. Palasonin, the active principle of *Butea monosperma* (Leguminosae; palas) @ 1 mg/ml was an effective anthelmintic against *Ascaris lumbricoides* using an in vitro assay (Lal et al., 1978).

Essential oils of *Boswellia serrata* (Burreaceae; kunder) and *Cinnamomum tamala* (Lauraceae; tejpat) had better in vitro activity than piperazine citrate against earthworms and tapeworms (Girgune et al., 1978). The essential oils of *Gardenia lucida* (Rubiaceae; dekamali) and *Cyperus rotendus* (Cyperaceae; mutha) has exhibited good anthelmintic activity against tapeworms and earthworms (Girgune et al., 1979). Varying degrees of anthelmintic efficacy of the essential oils of *Inula racemosa* (Compositae; rasan), *Psitacia integrrima* (Anacardiaceae; kak), *Litsea chinensis* (Lauraceae; medalakri) and *Randia dumetorum* (Rubiaceae; arara) seeds against earthworms and tapeworms have been reported (Mishra et al., 1979).

Essential oil from leaves and flowers of *Ageratum conyzoides* (Compositae; Pum-pillu) proved to be a very potent anthelmintic against tapeworms (Sharma et al., 1979). Essential oil of *Cyathocline lyrata* (Poaceae; local name not known) @ 0.1, 0.2 and 0.4% concentrations was found more effective against tapeworms and hookworms compared with piperazine phosphate and hexylresorcinol, respectively, and was comparably as effective as hexylresorcinol against nodular worms (Shrivastava, 1979). The essential oil of *Lantana camara* var. *aculeata* (Verbeuaceae; pulikampa) has exhibited good anthelmintic activity (Avadhoot et al., 1980). The anthelmintic activity of *Zanthoxylum alatum* has been found better than piperazine phosphate against earthworms and was comparable to that drug against roundworms (Mehta et al., 1981). Likewise, the essential oil from the fruits of *Zanthoxylum limonella* (Rutacae; local name not known) against earthworms, tapeworms and hookworms has been found better than that of piperazine phosphate (Kalyani et al., 1989).

The alcoholic extract of *Punica granatum* showed anthelmintic activity as revealed by a dose dependant inhibition of transformation of eggs to filariform larvae of *Haemonchus contortus* (Prakash et al., 1980). The fruit rind powder of *P. granatum* @ 3 g/kg, its equivalent water extract, and Morantel tartrate @ 0.01 g/kg were compared for their effectiveness against gastrointestinal nematodes of sheep; the reduction in EPG was 85, 80 and 99.96%, respectively. The anticestodal efficacy of the *P. granatum* fruit rind powder @ 3 g/kg, its equivalent water extract, and Nilzan (Levamisole hydrochloride+Oxyclozanide) @ 5 ml/15 kg were measured, respectively, at 76, 77 and 99.75% reduction in EPG in sheep naturally infected with mixed cestode species (Akhtar and Riffat, 1985a). The anticestodal efficacy of the glycosides (=225 mg/kg), alkaloids (=225 mg/kg b.w.) of *P. granatum* fruit rinds and Nilzan @ 5 ml/15 kg was 6±2, 95±12 and 100±0%, respectively in goats (Akhtar and Aslam, 1988). Therapeutic efficacy of *P. granatum* and *Cucurbita maxima* (Cucurbitaceae; tarbuz) against clinical cases of nematodiasis in calves has been documented (Pradhan et al., 1992).

Kaushik et al. (1981) evaluated extracts of 11 plants which proved lethal to *Ascaridia galli* in vitro includ-

ing those from *Amomum aromaticum* (Zingiberaceae; bari ilaichi) root and rhizome, *Ammora wallichii* stem, *Anthocephalus indicus* (Rubiaceae; kadamba) stem and bark, *Calamintha umberosa* (Labiatae; local name not known) plant, *Dalbergia latifolia* (Leguminosae; shishapa) stem and bark, *Datura quercifolia* (Solanaceae) fruit, *Datura metal* (Solanaceae; kaladhatura) plant, *Ficus religiosa* (Urticaceae; pipla) stem and bark, *Sentia myrtina* plant, and *Sumplocos crataegoides* (Sumplocos; lodar) leaves. The essential oils of *Callistemon viminalis* (Myrtaceae; bottle brush) and *Anacardium occidentale* (Anacardiaceae; kaju) produced greater efficacy against earthworms and tapeworms in vitro than piperazine phosphate. The activity of these oils against hookworms was comparable to that of hexylresorcinol (Garg and Kasera, 1982a, b). Anthelmintic activity of the essential oils of *Buddlea asiatica* (Loganiaceae; newarpati) and *Chloroxylon swientenia* (Rutaceae; bhirra) against earthworms, tapeworms, and hookworms has been reported (Dengre, 1982). The essential oil obtained from oleo-gum resin of *Commiphora mukul* (Buberaceae; guggal) has good anthelmintic activity against tapeworms and hookworms comparable to that of piperazine phosphate and hexylresorcinol (Kakrani and Kalyani, 1984).

Akhtar and Riffat (1984) evaluated the efficacy of *Melia azedarach* against gastrointestinal nematodes of goats. They have reported 99.4±12 and 90.2±16% reduction in EPG in *M. azedarach* fruit powder @ 30 mg/kg and Morantel tartrate @ 0.01 g/kg treated animals. In another study, *M. azedarach* fruit powder @ 20 mg/kg, its equivalent water extract, methanol extract, ethanol extract, and piperazine @ 200 mg/kg were found to reduce EPG in *Ascaridia galli* infected chickens by 57.8±2.4, 15.7±4.3, 18.5±1.8, 67.8±4.6 and 75±2%, respectively (Akhtar and Riffat, 1985).

The whole plant powder of *Fumaria parviflora* @ 2 g/kg, its water extract, ethanol extract and Morantel tartrate @ 0.01 g/kg were compared for their efficacy against Trichostrongylus, Haemonchus and Trichuris nematodes in sheep. The respective reductions in EPG were 99.6±0.13, 29±4, 99.8±0.08 and 99.8±0.3% (Akhtar and Javed, 1985). *Saussurea lappa* roots powder @ 2 g/kg, its equivalent water extract, methanol extract, and Morantel tartrate @ 0.01 g/kg reduced EPG by 99±21, 48±32, 100±21, and 100±36% in sheep infected with mixed species of nematodes (Akhtar and Hassan, 1985). Glycosides (=300 mg/kg) extracted from roots of *S. lappa* and Morantel tartrate @ 0.01 g/kg resulted in reduction of EPG by 93±11 and 92±8% in sheep, and 93±4 and 97±8% in buffalo-calves infected with mixed species of nematodes, respectively (Akhtar and Makhdoom, 1988).

Akhtar et al. (1985) reported 100±0, 100±0, 81±2, and 100±0% reduction in EPG in buffalo calves infected with *Neoascaris vitulorum* on day 15 PT treated with powdered *C. crista* seeds @ 4 g/kg or its equivalent methanol extract, water extract, and Morantel tartrate @ 0.01 g/kg, respectively. In another study, glycosides @ 200 mg/kg extracted from *C. crista* seeds and Morantel tartrate @ 10 mg/kg caused 94±8 and 100±0% reduction in EPG on day 15 PT in sheep (Akhtar and Aslam, 1989) having mixed nematode infection (predominantly *Haemonchus contortus*). The anthelmintic activity of powdered *C. crista* seeds and its water and methanol extracts was also reported in chickens (Fayoumi breed) infected with *Ascaridia galli* by Javed et al. (1994). That study reported 94±3, 98±1 and 100±0% reduction in EPG by day 15 PT in chickens treated with powdered *C. crista* seeds @ 50 mg/kg, its equivalent methanol extracts, and piperazine adipate @ 200 mg/kg, respectively. The water extract of *C. crista* seeds was comparatively ineffective (24±15% reduction in EPG).

The *Psoralea coylifolia* seed powder @ 2 g/kg, its equivalent water extract, methanol extract, and Morantel tartrate @ 0.01 g/kg caused reduction in EPG of mixed gastrointestinal nematodes in sheep on day 15 PT by 98±0.1, 99±0.09, 18±2, and 99.9±0.6%, respectively (Javed and Akhtar, 1986). Akhtar and Riffat (1986) reported anthelmintic efficacy of *Peganum harmala* against gastrointestinal cestodes of goats. The treatments; *P. harmala* seed powder @ 3 g/kg, its equivalent water and methanol extract, and Nilzan (Levamisole hydrochloride+Oxyclozanide) @ 5 ml/15 kg resulted in 100±0, 89±32, 92±41 and 98±62% reduction in EPG, respectively. *Morus alba* stem bark powder @ 3 g/kg, its equivalent water extract, methanol extract, and Morantel tartrate @ 0.01 g/kg b.w. were found to reduce EPG by 82±47, 79±69, 81±67 and 98±32%, respectively in sheep infected with mixed species of nematodes. Similar treatments except with Morantel tartrate replaced by Nilzan (Levamisole hydrochloride+Oxyclozanide) @ 5 ml/15 kg were used to treat

cestode infection in sheep. This resulted in reduction in EPG by 85±66, 70±33, 79±42 and 99±29% in respective treatment groups (Riffat et al., 1986).

Lagenaria siceraria seeds powder @ 3 g/kg, its equivalent water extract, methanol extract, and Niclosamide @ 100 mg/kg caused 89±14, 67±15, 81±13 and 91±13% reduction in EPG, respectively, in sheep infected with cestodes, predominantly being the Moniezia and Avitellina species (Akhtar and Riffat, 1987). The essential oil of *Aglaia odorattissima* (Meliaceae) has been found effective against earthworms (Nanda et al., 1987).

Taenil, a combination of Male fern (Filix mass) 30%, *M. phillipinensis* 25%, Barbrung 22%, Senna 10%, Ajwain 10%, Sounf 7.5%, @ 6 g/12 kg has been reported to be effective in expelling Taenia species and *Dipylidium caninum* in 56.7% (68/120) of dogs treated (John and Raghavan, 1987). Taenil @ 2 g/bird in feed was also found 100% effective in removing tapeworms of poultry within 1 week after treatment (Bhagerwal, 1989). Powdered *Hyoscyamus niger* (Solanaceae; ajwain) seeds @ 3 g/kg, its equivalent water extract, methanol extract, and powdered *Morringa oleifera* roots @ 3 g/kg, its equivalent water extract, methanol extract, and Oxfendazole @ 4.5 mg/kg reduced EPG by 95±5.6, 91.8±2.3, 85.5±9.8; and 94.4±2.6, 93.5±2.9, 91±3.5 and 98.8±1.3%, respectively, in sheep having mixed nematode infection (Akhtar and Ahmad, 1990).

The oil (hexane extract) from the flowers of *Artemesia scoparia* (Compositae) has exhibited good anthelmintic activity (Naqvi et al., 1991). The essential oil of *Limnophila conferta* (Scrophulariaceae) has exhibited good anthelmintic activity (Reddy et al., 1991). The essential oil of *Artemisia pallens* (Compositae) has shown strong anthelmintic activity against *Pheritima posthuma*, *Taenia solium* and *Ascaris lumbricoides* even better than piperazine phosphate (Nakhare and Garg, 1991). The essential oil from the flowers of *Eupatorium triplinerve* (Compositae; ayapana) has been shown to possess good efficacy against *Ascaris lumbricoides* and *Taenia solium* (Garg and Nakhare, 1993).

Akhtar and Ahmad (1992) reported 89.8±4.3, 80.3±4.3, 89.2±3.7 and 96±5% reduction in EPG on day 15 PT in Beetal goats infected with gastrointestinal cestodes treated with *Mallotus philippinensis* fruit powder @ 375 mg/kg, its equivalent water and methanol extracts, and Nilzan (Levamisole hydrochloride+Oxyclozanide) @ 5 ml/15 kg, respectively. However, *M. phillipinensis* was not found effective against gastrointestinal nematodes of goats (Jost et al., 1996).

Embellia seeds were found to be 100% effective in removing tapeworms of poultry. The evaluation was based on the absence of any worm, eggs or segments of tapeworms in feces of chickens 1 week after the administration of Embellia seeds as pills compared with the pre-treatment presence of parasitic forms (Qureshi and Sabir, 1979). Various extracts of *Vernonia anthelmintica* have been tested for their anthelmintic activity. Alcoholic extract has been found to possess maximum anthelmintic activity, followed by etheral extract, whereas, aqueous extract has no anthelmintic activity (Singh et al., 1985). The antinematodal activity of a mixed prescription of *Vernonia anthelmintica* seed (kali zeeri) and *Embellia ribes* fruit (babrung) was evaluated in goats by Javed and Akhtar (1990). The results revealed that EPG was reduced by 83±2, 27±3, 93±3 and 99.8±0.06% when goats were treated with mixed prescription @ 2 g/kg powder, its equivalent water extract, methanol extract, and Morantel tartrate @ 0.01 g/kg, respectively.

The essential oils from the leaves of *Artabotrys odoratissimus* (Annonanceae; madan mast), inflorescence of *Capillipedium foetidum* (Poaceae) and the grass of *Cymbopogon martini* (Poaceae; lemon grass or rusa grass) have been reported to possess better anthelmintic activity compared to piperazine phosphate against *Pheretima posthuma* (earthworms), *Taenia solium* and *Ascaris lumbricoides* (Siddiqui and Garg, 1990).

The anthelmintic studies on the essential oils of *Nigella sativa* against earthworms, tapeworms, hookworms and nodular worms have exhibited fairly good activity against earthworms and tapeworms, the activity against hookworms and nodular worms being comparable with that of hexylresorcinol (Agarwal et al., 1979). *Nigella sativa* seeds powder @ 2.5 g/kg, its equivalent water extract, ethanol extract and Niclosamide @ 0.1 g/kg caused 99±0.03, 74±4, 99±0.02 and 100±0.6% reduction in EPG of Moniezia in sheep (Akhtar and Javed, 1991). The active principles of *N. sativa* have also been evaluated for their anticestodal efficacy in goats. Glycosides (=200 mg/kg), Saponins (=200 mg/kg), Anthraqui-

nones (=200 mg/kg) of *N. sativa*, and Nilzan @ 5 ml/15 kg reduced EPG by 94±5, 8±4, 6±3 and 97±4%, respectively (Akhtar and Aslam, 1997).

Kailani et al. (1995) evaluated antifasciolic efficacy of powdered *Nigella sativa* seeds, *Fumaria parviflora* aerial parts, and *Caesalpinia crista* seeds in buffaloes. Maximum antifasciolic efficacy, judged on the basis of per cent reduction in EPG was shown by *F. parviflora* @ 60 mg/kg (93.2±0.5%) followed by *C. crista* @ 40 mg/kg (89.7±1.7%) and *N. sativa* @ 25 mg/kg (88.2±0.4%) at day 15 post-treatment (PT).

5. Conclusions

A wide variety of plants are naturally available in the Indo–Pakistan subcontinent which possess narrow or broad spectrum anthelmintic activities. No doubt this is true in other regions of the world as well where gastrointestinal parasitism is an important problem in livestock keeping, and the availability of commercial drugs may be limited. The phytochemical analyses of these plants and controlled anthelmintic trials along with contemporary knowledge of parasite control strategies may offer new opportunities for effective and economical control of parasitic diseases.

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