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Ethiopian traditional herbal drugs. Part I: Studies on the toxicity and therapeutic activity of local taenicidal medications

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Abstract

The quantitative toxicities of 33 taenicidal herbal drugs are presented, expressed as their intraperitoneal LD_{50} values in mice and their respective median effective oral dose and worm expulsion time in humans. Rank orders of toxicity, taenicidal potency and worm expulsion time of the herbal medications are indicated along with a discussion of their respective therapeutic merits and untoward effects. On the basis of considerations of lower toxicity, higher potency and shorter worm expulsion time, the taenicidal herbal medications are arranged in decreasing rank order of preference. Other therapeutic uses of the herbs are also presented and discussed.

Keywords: Taenicidal herbs; Anthelmintics; Taeniasis; Traditional herbal drugs; Ethiopian herbs

1. Introduction

Taeniasis is a parasitic infestation of the intestinal tract by the cestode, *Taenia saginata* L. (Taeniidae) (Wallace, 1963). The infection is caused by the ingestion of raw or insufficiently cooked beef. The condition is also known as beef tapeworm infection. Ingestion of the tapeworm cysts (cysticercus stage) in the striated muscle of raw or undercooked beef by humans is followed by the development of the cyst into the adult worm, which then inhabits the human intestinal tract. The adult worm consists of a small head (scolex) 1–2 mm in diameter and up to 1000 hermaphroditic proglottides (segments) that give the worm its characteristic ribbon-like shape (Berkow, 1987). The worm can be 4.5–9 m (15–30 ft) long. The egg-bearing proglottides are passed in the stool and ingested by cattle, where the eggs hatch, invade the intestinal wall and are subsequently carried by the bloodstream to striated muscle in which they are encysted, to await resumption of the new cycle (Berkow, 1987).

The infection is asymptomatic, even though epigastric pain, nausea, diarrhoea and weight loss may occur. Sometimes the patient may detect a detached active proglottid crawling out of the anus. The sensation of fullness and/or discomfort in the gastrointestinal tract, proglottides in the stool or a microscopic finding of eggs in stool samples are used in making a diagnosis (Wallace, 1963).

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The long standing tradition of eating raw meat (beef) in Ethiopia has established in the majority of the people a craving for raw beef. This custom is so rampant and the tapeworm infestation so extensive that over 80% of the adult population have to take a tapeworm expellant (taenicidal medication) every 3 months or so, since the undetached scolex takes about 12 weeks to grow in length and start shedding individual proglottids (Rollo, 1970). The finding of a crawling proglottid on one's person is taboo and is associated with a great deal of shame — so much so that the administration of taenicidal herbal drugs to brides and expectant mothers is an important aspect of pre-nuptial and pre-childbirth rites. The recurrent necessity of removing the worm from the body, therefore, has brought forth the use of a large variety of taenicidal herbs in different parts of the country. The regular intake of these different taenicidal herbs has also been associated with a variety of side effects, including liver disease (Tsega, 1977), gastrointestinal ailments (Chernishov and Aragie, 1978) and eye complications (Rokos, 1969). A systematic scientific study of the taenicidal herbs has not been made and this paper is, therefore, a report of an attempt to study the toxicity, relative efficacy and other therapeutic activities of the taenicidal herbs commonly used in Ethiopia.

2. Materials and methods

2.1. Plant acquisition

The plants in this study were collected by the author from their natural habitats (the Northwestern, Western and Southern highlands as well as from the Rift Valley areas of Ethiopia (500–3000 m)). Botanical identifications were made by Dr. Thomas Jenkins of the Department of Plant Science, Alemaya University (Ethiopia). Voucher specimens were prepared under the expert supervision of Dr. T. Jenkins and have been deposited at the Herbarium of Medicinal Plants of the School of Pharmacy of the Addis Ababa University. The herbs were dried in the shade and all phytochemical work was done using known amounts of dried samples of herb material.

2.2. Preparation of aqueous and hydroalcoholic extracts

The dried herb material was pulverized to a course powder by means of a milling machine. The dried and powdered material was extracted by percolation as follows:

1. An amount equivalent to 0.5 kg of the powdered material was moistened thoroughly with distilled water in a large evaporating dish. The moistened sample was set aside for half an hour.
2. The moistened plant material was transferred to a glass percolator and lightly packed. A piece of filter paper was placed on top of the packing, with a few glass beads added to anchor it.
3. Distilled water or a hydroalcoholic solution (15% v/v ethanol) was added to the top of the plant material until the percolate began to drip from the bottom of the percolator. The percolation was then stopped and more menstruum (the extracting solvent) was added in quantities sufficient to cover the top of the packed plant material. The percolation set-up was set aside for 1 h in order to ensure solvent saturation of the plant material.
4. The extractive was then eluted at the rate of 0.5 ml/min (making sure that the top of the sample was always covered by the menstruum) until 250 ml of the eluate (percolate) had been collected. The percolate (fluid extract) was then lyophilized, weighed and put in a tightly stoppered bottle and stored in a desiccator under refrigeration.

2.3. Administration of herbal drugs to mice

An exact amount of the lyophilized sample was weighed out and a sufficient volume of distilled water or hydroethanolic solvent (15% v/v ethanol in water) was added to give a 20% w/v solution of the test material (calculated in terms of dried starting material). On the basis of the results using the initial concentration (20% w/v of crude drug solution), subsequent batches of mice were administered intraperitoneally (i.p.), solutions having dose levels of either one-half or double the original dose, until a situation had been documented in which all of the mice in the group survived for 24 h and another situation was seen in which all of the mice were found dead after 24 h. Solutions of samples that were used for injection into the mice were freshly prepared each day.

2.4. Experimental animals

Adult albino mice (Pasteur Institute, Addis Ababa, Ethiopia) of both sexes, having a weight of over 20 g were used. The animals were provided with standard pellet food and water ad libitum. The animals were put in groups (10 mice/group) and given i.p. injections of the different concentrations of the herbal solutions or of the dosing vehicle (controls). After injection, the animals were observed the first 24 h for signs of behavioral, neurological and autonomic manifestations, as described in the literature (Bushby, 1963; Turner, 1965). The number of dead mice in each group was recorded at the end of the 24th hour.

The LD_{50} values were determined using the method of Behrens and Kurber (Belenskii, 1964). Mice which were found dead were necropsied and the visceral organs and surrounding tissues were examined for gross pathological changes.

2.5. Determination of taenicidal activity

An amount of powdered herbal plant material, equivalent to that usually used traditionally, was weighed out and mixed with honey in a sufficient amount to make it palatable. In the morning, the paste was administered orally to the 6 human volunteers in a dose group as a single dose on an empty stomach, immediately followed by a glass of water. Food and drinks were withheld for 6 h. The initial dose was progressively decreased or increased until no worm expulsion was seen in all 6 worm-infected volunteers of a group or until worm expulsion (partial or total) was effected in all (100%) of the treated volunteers of a dose group. The worm expulsion time (number of hours elapsed since the time of drug administration) was noted for each test material. The expelled worm was checked for the presence of the scolex. The percent of volunteers (in any one group) that had expelled worms was plotted against the dose of taenicidal herbal material, and the amount that was found to effect expulsion of the worm in 50% of the volunteers was calculated. The tests were carried out on volunteers who had detected worms in their stool, but were otherwise healthy. The taenicidal herbs that were administered to the volunteers were the ones that were customarily taken by the individual volunteers according to the preferences of the specific region of the country, so that ethical requirements in tests with humans were not violated.

2.6. Other therapeutic uses

On the basis of responses obtained from members of different communities in various parts of Ethiopia and traditional herbalists, a list of other therapeutic uses of the taenicidal herbs were also compiled.

3. Results and discussion

The results of the toxicity studies in mice of 33 taenicidal herbal drugs are shown in Table 1. It can be seen that the LD_{50} values for the aqueous extracts range from 78.9 mg/kg for *Echinops gigantea* to > 5000 mg/kg for *Cucurbita pepo*. The LD_{50} values for the hydroalcoholic extracts lie in the range of 70.2–> 5000. An examination of the 10 most frequently used taenicidal herbs indicates a decreasing toxicity rank order of: *Echinops gigantea, Glinus lotoides, Hagenia abyssinica, Plantago lanceolata, Embelia schimperi, Myrsine africana, Thymus serrulatus, Maesa lanceolata, Cynodon dactylon* and *Cucurbita pepo*, for the aqueous extracts. The decreasing toxicity rank order of the hydroalcoholic extracts of the same 10 most frequently used taenicidal herbs is: *Echinops gigantea, Glinus lotoides, Hagenia abyssinica, Maesa lanceolata, Plantago lanceolata, Cynodon dactylon, Embelia schimperi, Myrsine africana, Thymus serrulutus* and *Cucurbita pepo*. It can be seen that 4 of the 10 herbs have the same rank order (1, 2, 3 and 10) for both the aqueous and hydroalcoholic extracts, while the rank orders for the other 6 herbs show only minor differences. It may be surmised that the traditional use of either the aqueous or hydroalcoholic extracts (according to individual preference) is based on comparable orders of solubility and hence similar magnitudes of therapeutic effect of the active ingredients. It is to be noted that the commonly available traditional alcoholic beverages used in the preparation of taenicidal dosage forms have an alcoholic content of up to 15% v/v; this is why that alcohol concentration was used for the hydroalcoholic extracts in this study.

A comparison of the LD_{50} values for the aqueous extracts and the hydroalcoholic extracts shows that the values vary, probably depending on the relative solubility of the active and/or toxic constituents in either extract. The results indicate that out of the 33 herbs, the aqueous extract of 10 herbs have LD_{50} values that are greater than those of the hydroalcoholic extracts of the corresponding herbs. In the case of the remaining 22 herbs, the LD_{50} values for the hydroalcoholic extracts are greater than those of the aqueous extracts of the corresponding herbs. In one case the LD_{50} values were over 5000 mg/kg for both the aqueous and hydroalcoholic extracts. It may generally be commented that most of the herbs are of rather low toxicity in the amounts that they are usually used

Table 1
Quantitative toxicity in mice of aqueous and hydroalcoholic extracts of traditional taenicidal herbal drugs given intraperitoneally

VHS No.[a]	Scientific name	Plant part[b]	LD_{50} ± 95% Confidence limits (mg/kg)	
			Aqueous extract	Hydroalcoholic extract
152	*Albizia anthelmintica* (Rich) A. Brongn (Leguminosae)	Bk	3046 ± 261	3281 ± 286
148	*Aningeria adolfifriedericii* (Engl) Rob & Gilb (Sapotaceae)	Fr	1311 ± 241	1893 ± 201
98	*Asparagus aethiopicus* Lam. (Lilaceae)	Rt	2686 ± 310	2987 ± 202
52	*Berchemia discolor* (Klotzsch) Hemsl (Rhamnaceae)	Lf	1841 ± 254	2844 ± 283
48	*Commiphora resiniflua* Martelli (Burseraceae)	Rs	2541 ± 246	3128 ± 181
42	*Croton macrostachys* Hochst. ex A. Rich. (Euphorbiaceae)	Bk	190.2 ± 15.7	87.5 ± 12.3
38	*Cucurbita pepo* L. (Cucurbitaceae)	Sd	>5000	>5000
54	*Cussonia* sp. (Araliaceae)	Bk	850.5 ± 31.2	1044 ± 136
72	*Cynodon dactylon* (L.) Pers. (Gramineae)	Wp	4932 ± 389	3822 ± 319
84	*Dodonea viscosa* (L.) Jacq. (Sapindaceae)	Lf	285.5 ± 10.4	322.3 ± 14.2
12	*Echinops gigantea* A. Rich. (Compositae)	Rt	78.92 ± 4.25	70.23 ± 3.84
8	*Echinops* sp. (Compositae)	Rt	3864 ± 376	4028 ± 248
10	*Embelia schimperi* Vatke (Myrsinaceae)	Fr	3642 ± 328	4237 ± 278
25	*Galium* sp. (Rubiaceae)	Lf	2049 ± 246	1923 ± 201
14	*Glinus lotoides* L. (Aizoaceae)	Fr	532.6 ± 28.3	1811 ± 108
26	*Grewia ferruginea* Hochst ex A. Rich. (Tiliaceae)	Bk	2520 ± 198	1825 ± 244
140	*Guizotia scabra* (Vis.) Chiov. (Compositae)	Rt	783.4 ± 20.4	1023 ± 103
16	*Hagenia abyssinica* (Bruce) Gmel. (Rosaceae)	Fl	2014 ± 301	1980 ± 179
21	*Helichrysum schimperi* Sch. Bip. ex Rich. (Compositae)	Rt	1054 ± 102	1782 ± 199
20	*Jasminum abyssinicum* Hochst ex DC. (Oleaceae)	Rt	428.4 ± 16.9	673.3 ± 198
19	*Kalanchoe quartiniana* A. Rich. (Crassulaceae)	Rt	1046 ± 172	924.6 ± 105
30	*Maesa lanceolata* Forsk. (Myrsinaceae)	Fr	4847 ± 450	3218 ± 388
22	*Myrsine africana* L. (Myrsinaceae)	Fr	4478 ± 392	4692 ± 291
18	*Plantago lanceolata* L. (Plantaginaceae)	Wp	2980 ± 189	3350 ± 326
29	*Prunus persica* (L.) Stokes (Rosaceae)	Lf	1211 ± 120	1453 ± 240
33	*Punica granatum* L. (Punicaceae)	Rt	1858 ± 194	2031 ± 182
79	*Rhamnus staddo* A. Rich. (Rhamnaceae)	Lf	1246 ± 180	2014 ± 204
11	*Ricinus communis* L. (Euphorbiaceae)	Rt	845.8 ± 30.6	726.1 ± 49.8
44	*Securidaca longepedunculata* Fresen (Polygalaceae)	Rt	726.8 ± 38.4	901.2 ± 28.7
31	*Smilax goetzeana* Engler (Smilaceae)	Rt	2544 ± 221	1862 ± 146
118	*Solanum marginatum* L. (Solanaceae)	Rt	674.5 ± 19.5	781.4 ± 69.2
128	*Syzgium guinensis* (Willd.) DC. (Myrtaceae)	Rt	928.5 ± 104	1175 ± 92.4
56	*Thymus serrulatus* Hochst. ex Benth. (Labiatae)	Lf	4682 ± 406	4876 ± 308

[a]VHS No. indicates the voucher herbarium specimen number.
[b]Bk, bark; Fl, flower; Fr, fruit; Lf, leaf; Rt, root; Rs, resin; Sd, seed; Wp, whole plant.

in traditional taenicidal therapy. However, the LD_{50} values for *Echinops gigantea, Croton macrostachys, Dodonia viscosa, Jasminum abyssinicum, Glinus lotoides, Solanum marginatum, Securidaca longepedunculata, Guizotia schimperi, Ricinus communis, Cussonia* sp. and *Syzgium guinensis* appear to correlate with higher frequencies of complaints about untoward effects collected from traditional users of these herbs. The higher intraperitoneal doses of the extracts showed decreased motor activity and muscle tone with varying degrees of neurological effects. However, no marked pathological changes were seen when these experimental animals were necropsied. The LD_{50} value (> 8000 mg/kg) obtained for ethanol, under the same experimental conditions precludes any major contribution to the toxicity by the non-aqueous solvent.

The median effective single dose (the dose that expels the worm, partially or totally, in 50% of

Table 2
Therapeutic oral effectiveness in humans of traditional taenicidal herbal drugs

Scientific name	Plant part[a]	Mean ± 95% Confidence limits		Other therapeutic uses
		Median effective single dose (g)	Worm expulsion time (h)	
Albizia anthelmintica	Bk	21.4 ± 0.8	22.8 ± 2.7	Anthelmintic
Aningeria adolfifriedericii	Fr	22.1 ± 3.0	30.0 ± 3.4	Antibacterial
Asparagus aethiopicus	Rt	14.8 ± 1.8	14.2 ± 3.1	Antihypertensive
Berchemia discolor	Lf	16.7 ± 2.4	22.1 ± 2.4	Hepatotonic
Commiphora resiniflua	Rs	52.3 ± 6.3	16.8 ± 1.9	Hepatotonic
Croton macrostachys	Bk	6.42 ± 0.82	12.9 ± 2.1	Purgative
Cucurbita pepo	Sd	42.8 ± 5.3	10.1 ± 1.7	Antipyretic
Cussonia sp.	Bk	20.3 ± 2.1	23.4 ± 2.1	Antifilariasis
Cynodon dactylon	Wp	35.7 ± 2.5	14.8 ± 0.8	Uricosuric
Dodonea viscosa	Lf	15.5 ± 2.4	13.2 ± 1.2	Anti-snakebite
Echinops gigantea	Rt	7.84 ± 1.04	10.2 ± 2.0	Antihemorrhoidal
Echinops sp.	Rt	15.6 ± 2.0	14.2 ± 2.2	Antipyretic
Embelia schimperi	Fr	8.23 ± 1.50	10.8 ± 1.0	Disinfectant
Galium sp.	Lf	20.1 ± 2.1	20.3 ± 0.8	Antipityriasis
Glinus lotoides	Fr	15.6 ± 1.9	12.4 ± 1.8	Antidiabetic
Grewia ferruginea	Bk	24.3 ± 2.7	25.7 ± 1.7	Scabicide
Guizotia scabra	Rt	13.2 ± 0.8	19.8 ± 1.9	Antimicrobial
Hagenia abyssinica	Fl	12.5 ± 2.2	11.3 ± 1.4	Antihypertensive
Helichrysum schimperi	Rt	30.2 ± 1.3	21.6 ± 0.9	Anthelmintic
Jasminum abyssinicum	Rt	25.3 ± 1.5	21.4 ± 2.2	Snake repellant
Kalanchoe quartiniana	Rt	24.6 ± 1.4	12.6 ± 0.6	Anti-inflammatory
Maesa lanceolata	Fr	40.9 ± 3.2	12.4 ± 2.6	Antimicrobial
Myrsine africana	Fr	30.2 ± 2.2	12.1 ± 2.1	Anti-inflammatory
Plantago lanceolata	Wp	60.2 ± 4.9	18.0 ± 2.4	Antibacterial
Prunus persica	Lf	15.2 ± 1.8	15.2 ± 1.7	Anti-inflammatory
Punica granatum	Rt	12.6 ± 0.9	16.7 ± 1.8	Anti-inflammatory
Ricinus communis	Rt	22.4 ± 2.7	9.83 ± 1.10	Antibacterial
Rhamnus staddo	Lf	24.2 ± 1.5	16.3 ± 2.3	Anthelmintic
Securidaca longepedunculata	Rt	12.4 ± 1.2	20.3 ± 1.9	Antitussive
Smilax goetzeana	Rt	31.6 ± 2.4	14.2 ± 1.5	Antispasmodic
Solanum marginatum	Rt	18.4 ± 1.7	10.2 ± 0.8	Antimicrobial
Syzgium guinensis	Rt	30.1 ± 1.9	16.6 ± 2.0	Anthelmintic
Thymus serrulatus	Lf	20.6 ± 2.1	11.2 ± 1.1	Hepatotonic

[a]Bk, bark; Fl, flower; Fr, fruit; Lf, leaf; Rt, root; Rs, resin; Sd, seed; Wp, whole plant.

worm-infested subjects) for each of the 33 traditionally used taenicidal herbs is shown in Table 2. This table shows that the median effective single doses of the 33 herbs range from 6.4 g for *Croton macrostachys* to 60.2 g for *Plantago lanceolata*. The experimental results for the 10 most frequently used taenicidal herbs indicate a decreasing potency rank order of: *Echinops gigantea, Embelia schimperi, Hagenia abyssinica, Glinus lotoides, Thymus serrulatus, Myrsine africana, Cynodon dactylon, Maesa lanceolata, Cucurbita pepo* and *Plantago lanceolata*. A comparison of this potency rank order with the decreasing toxicity rank order in mice of the aqueous extracts indicates that the same herbs appear as: 1 (*Echinops gigantea*), 3 (*Hagenia abyssinica*), 6 (*Myrsine africana*) and 8 (*Maesa lanceolata*). In the case of the hydroalcoholic extracts rank order correlations were observed only in *Echinops gigantea* (1) and *Hagenia abyssinica* (3).

The number of hours that elapse before partial or total expulsion of the worms, following admin-

Table 3
Decreasing order of preference[a] of Ethiopian taenicidal herbal drugs and their traditional human dosage forms

Local name	Scientific name	Plant part[b]	Traditional dosage form
Enkkokko	*Embelia schimperi*	Fr	Aqueous or hydroalcoholic extract
Ttossigne	*Thymus serrulatus*	Lf	Paste in honey
Kosso	*Hagenia abyssinica*	Fl	Aqueous or hydroalcoholic extract, paste in honey
Yeset-Kkest	*Asparagus aethiopicus*	Rt	Paste in honey
Kkeberitcho	*Echinops sp.*	Rt	Paste in honey
Duba	*Cucurbita pepo*	Sd	Slightly fried and salted seeds
Dendero	*Echinops gigantea*	Rt	Paste in honey
Kkettchemo	*Myrsine africana*	Fr	Paste in honey
Kkelewa	*Maesa lanceolata*	Fr	Aqueous or hydroalcoholic extract
Roman	*Punica granatum*	Rt	Hot water extract
Missana	*Croton macrostachys*	Bk	Paste in honey
Geber-Emboiy	*Solanum marginatum*	Rt	Paste in aqueous sunflower extract
Ttchakkma	*Ricinus communis*	Rt	Paste in aqueous sunflower extract
Kok	*Prunus persica*	Lf	Paste in aqueous linseed extract
Serdo	*Cynodon dactylon*	Wp	Paste in honey
Metterie	*Glinus lotoides*	Fr	Aqueous or hydroalcoholic extract
Kitkita	*Dodonea viscosa*	Lf	Juice or paste in honey
Yahiya-Enkoko	*Smilax goetzeana*	Rt	Paste in honey
Ashkit	*Galium sp.*	Lf	Juice with honey
Andahula	*Kalanchoe quartiniana*	Rt	Paste in aqueous sunflower extract
Shina	*Albizia anthelmintica*	Bk	Paste in honey
Mettche	*Guizotia scabra*	Rt	Paste in aqueous sunflower extract
Harmal	*Securidaca longepedunculata*	Rt	Paste in honey
Dilesis	*Berchemia discolor*	Lf	Paste in honey
Ttedo	*Rhamnus staddo*	Lf	Aqueous or hydroalcoholic extract
Gortteb	*Plantago lanceolata*	Wp	Hot water extract
Ankket	*Commiphora resiniflua*	Rs	Hot water extract
Lenkkuatta	*Grewia ferruginea*	Bk	Paste in aqueous sunflower extract
Dokkma	*Syzgium guinensis*	Rt	Hot water extract
Kkerero	*Aningeria adolfifriedericii*	Fr	Paste in barley porridge
Getemie	*Cussonia sp.*	Bk	Hot water extract
Serareti	*Helichrysum schimperi*	Rt	Hot water extract
Ttembelel	*Jasminum abyssinicum*	Rt	Paste in aqueous sunflower extract

[a]On the basis of relative low toxicity, high potency and short worm expulsion time.
[b]Bk, bark; Fl, flower; Fr, fruit; Lf, leaf; Rt, root; Rs, resin; Sd, seed; Wp, whole plant.

istration of the taenicidal herbs (worm expulsion time) is also shown in Table 2. It can be seen that the worm expulsion time covers a range of 9.8 h (for *Ricinus communis*) to 30.0 h (for *Aningeria adolfifriedericii*). It is interesting to note that more than 90% of the taenicidal herbs that were studied are associated with a worm expulsion time of less than 24 h. This is quite significant in the sense that, traditionally, it is highly preferable that taeniasis treatment be resolved in one day (during the treatment day or the following night).

For the 10 most commonly used taenicidal herbs, the rank order of increasing worm expulsion time was found to be: *Cucurbita pepo, Embelia schimperi, Thymus serrulatus, Hagenia abyssinica, Myrsine africana, Maesa lanceolata, Glinus lotoides, Echinops gigantea, Cynodon dactylon* and *Plantago lanceolata*. All of the 10 herbs had a worm expulsion time of not more than 18 h. On the basis of equal considerations of toxicity, potency and worm expulsion time, in other words, in terms of lower toxicity, higher potency and shorter worm-expulsion time, the 10 most frequently used taenicidal herbs emerge in decreasing order of preference as follows: *Embelia schimperi, Cucurbita pepo, Thymus serrulatus, Hagenia abyssinica, Myrsine africana, Maesa lanceolata, Cynodon dactylon, Echinops gigantea, Glinus lotoides* and *Plantago lanceolata*. Likewise, the decreasing rank order of preference for all of the 33 taenicidal herbs is shown in Table 3.

Other therapeutic uses of the taenicidal herbs are shown in Table 2. That the beneficial effects of these herbs are also associated with such indications as: hypertension, diabetes, filariasis, liver diseases, inflammatory diseases, microbial infections etc. increases the overall significance of these medications.

4. Conclusions

It is evident that the problem of taeniasis can be resolved by developing clean enclosed pastures for cattle and/or by eating cooked beef. Pending the gradual change of national habits, it is, however, necessary that taenicidal medications be developed from the standpoint of availability, low toxicity, high potency and short worm expulsion time. The results in this investigation appear to indicate that further studies in this regard will be worthwhile.

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