

Asteracantha longifolia (L.) Nees, Acanthaceae: chemistry, traditional, medicinal uses and its pharmacological activities - a review

Nagendra Singh Chauhan,* V. K. Dixit

Department of Pharmaceutical Sciences, Dr. H. S. Gour University, Vishwavidyalaya Campus, Sagar M.P. 470003 India.

RESUMO: “*Asteracantha longifolia* (L.) Nees, Acanthaceae: química, usos tradicionais e medicinais e suas atividades farmacológicas – uma revisão.” *Asteracantha longifolia* (L.) Nees, Acanthaceae, é a fonte do medicamento ayurvédico “Kokilaaksha”, e da droga Unani, Talimakhana. As sementes têm de sabor acre e amargas, são afrodisíacas, tônicas, calmantes, e usadas para doenças do sangue. A planta é conhecida por possuir propriedades antitumorais, hipoglicêmica, afrodisíaca, anti-bacteriana, na eliminação de radicais livres e peroxidação lipídica, atividade hepatoprotetora e hematopoiéticas. Ele contém lupeol, estigmasterol, butelina, ácidos graxos e alcaloides. Este trabalho apresenta estudos químicos, farmacológicos e outros aspectos importantes da Talimakhana.

Unitermos: *Asteracantha longifolia*, Rasayana, afrodisíaco, tônico.

ABSTRACT: *Asteracantha longifolia* (L.) Nees, Acanthaceae, is a source of the ayurvedic drug, ‘Kokilaaksha’ and the Unani drug, Talimakhana. The seeds are acrid, bitter, aphrodisiac, tonic, sedative, used for diseases of the blood. The plant is known to possess antitumor, hypoglycemic, aphrodisiac, antibacterial, free radical scavenging and lipid peroxidation, hepatoprotective and haematopoietic activity. It contains lupeol, stigmasterol, butelin, fatty acids, and alkaloids. The present review article is focused on phytochemical, pharmacological and other important aspects of Talimakhana.

Keywords: *Asteracantha longifolia*, Rasayana, aphrodisiac, tonic.

INTRODUCTION

Rasayana is the special category of the drugs of Indian system of medicine Ayurveda. The word Rasayana is composed of two words ‘Rasa’ meaning elixir and ‘Ayana’ meaning house. The word therefore signifies property of the plant that helps to rejuvenate the system. Many plants have been broadly used as ‘Rasayana’ drugs in Ayurveda for the management of neurodegenerative diseases, as rejuvenators, immunomodulators, aphrodisiac and tonic (Thakur et al., 2007). The *Asteracantha longifolia* (L.) Nees, Acanthaceae, finds mention in Ayurvedic treatise like ‘Sushruta Samhita’ and ‘Charak Samhita’ as Rasayan or rejuvenator. *A. longifolia* is described in ayurvedic literature as Ikshura, Ikshugandha, and Kokilasha “having eyes like the Kokila or Indian Cuckoo”. They are also constituent of ayurvedic formulation “Strirativalabhupugpak” and “Rativardhanyog” described in ancient text to improve sexual behaviour and as a general tonic (Vaidya, 1970).

The present article includes the detailed exploration of pharmacological and phytochemical properties of *A. longifolia* as an attempt to provide a direction for further research.

Synonyms

Hygrophila auriculata (Schumach.) Heine.,
Hygrophila spinosa T. Anders.

Vernacular names

Sanskrit: Iksura; Bengali: Kuliakhara; Gujarati: Ekharo; Hindi: Talmakhana; Malayalam: Nirmuli; Marathi: Talimakhana; Tamil: Golmidi and Urdu: Talmakhana.

Geographical sources

The plant is widely distributed throughout India, Srilanka, Burma, Malaysia and Nepal.

General description

It is a spiny, stout, annual herb, common in water logged places. Leaves sessile, oblong-lanceolate or linear lanceolate, spines yellowish brown, 2-3 cm long, Flower yellowish brown, fruit two celled, linear oblong, compressed about 8 cm long, pointed, 4-8 seeded (Figure 1). Seed ovate, flat or compressed, 0.2-0.25 cm long and 0.1-0.15 cm wide, hairy but appearing smooth; when soaked in water immediately get coated with mucilage, light brown: taste slightly bitter and odour not distinct (The Ayurvedic Pharmacopoeia of India, 1999).

Quantitative standards

Foreign matter: Not more than 2.0 percent. Ash: Not more than 8.5 percent. Acid-insoluble ash: Not more than 3.5 percent. Ethanol soluble extractive: Not more than 13.0 percent. Water soluble extractive: Not more than 17.0 percent (Gupta et al., 2006).

Taxonomical information

Class: Equisetopsida C. Agardh
Subclass: Magnoliidae Novák ex Takht.
Superorder: Asteranae Takht.
Order: Lamiales Bromhead
Family: Acanthaceae Juss.
Genus: *Asteracantha* Nees
Species: *Asteracantha longifolia* (L.) Nees

Traditional uses

The whole plant, roots, seeds, and ashes of the plant are extensively used in traditional system of medicine for various ailments like rheumatism, inflammation, jaundice, hepatic obstruction, pain, urinary infections, oedema and gout. It is classified in ayurvedic system as seethaveeryam, mathuravipaka and used for the treatment of premeham (diabetes), athisaram (dysentery) etc (Nadkarni, 1978; Chopra et al., 1986).

Pharmacological activities

Hypoglycemic activity

Ethanol extract (Al Eth) of aerial parts of *A. longifolia* (100 and 250 mg/kg body weight) when administered to rats for three weeks showed significant reduction in blood glucose level. There is also decrease in thiobarbituric acid reactive substances (TBARS) and hydroperoxide in both liver and kidney. The treatment with Al Eth significantly increased the glutathione (GSH), glutathione peroxidase (GPx), glutathione S-transferase (GST) and catalase (CAT) in the drug-treated group,

which is comparable to the control group. Al Eth treated rats also showed decreased lipid peroxidation that is associated with increased activity of superoxide dismutase (SOD) and catalase (Vijayakumar et al., 2006). Fernando et al. (1991) investigated the effects of hotwater extracts of *A. longifolia* whole plant material on the glucose tolerance of normal human subjects and maturityonset diabetic patients. Administration of aqueous extract of *A. longifolia* to rats prior to glucose loading showed hypoglycemic action as it was significant increase in the glycogen content of liver and muscle and a significant increase in triacylglycerol content of adipose tissue in comparison with control rats. However, the plant extract had no effect on the gluconeogenic capacity of the kidney or intestinal glucose absorption (Fernando et al., 1998, Fernando et al. 1989).

Hepatoprotective activity

The aqueous extract of whole plant and root of *A. longifolia* possesses hepatoprotective and antioxidative properties against CCl₄- and paracetamol-induced hepatotoxicities (Hewawasam et al., 2003, Usha et al., 2007). Petroleum ether extract of *A. longifolia* affects liver and kidney functions and metabolism and hematological parameters in high doses (40 and 80 mg/kg) whereas low weekly dose (20 mg/kg) and low and moderate daily/therapeutic dose (2 and 4 mg/kg) does not exhibit any appreciable toxic action (Mazumdar et al., 1996). Methanolic extracts of the seeds show hepatoprotective activity against paracetamol and thioacetamide intoxication in rats (Singh & Handa, 1999). Ahmed et al. (2001) studied the against of seeds against chemically induced hepatocarcinogenesis in Wistar rats. Methanol extract of seed showing antitumor promoting potential inhibit hepatocarcinogenesis in Wistar rats, increase GPx and CAT, ODC. Shivashangari et al. (2004) studied the protective efficacy of *A. longifolia* on acetaminophen-induced liver damage in rats. Shanmugasundaram & Venkataraman (2006) studied the aqueous extract of the roots for hepatoprotective in CCl₄-induced liver toxicity in rats and in vitro antioxidant activity using ferric thiocyanate (FTC) and thiobarbituric acid (TBA) methods. Shailajan et al. (2005) showed the whole plant slurry of *A. longifolia* was hepatoprotective activity against CCl₄ induced liver dysfunction in rats. Later they also reported that the slurry, aqueous extract and ethanolic extract of whole plant powder showed hepatoprotective effect against galactosamine induced hepatotoxicity (Shailajan et al. (2007).

Anti-nociceptive

The aqueous extract of aerial parts and root for its anti-nociceptive property using both chemical and thermal methods of nociception in mice (Shanmugasundaram &

Venkataraman, 2005). Chloroform and alcoholic extracts of *A. longifolia* leaves have anti-inflammatory, analgesic and antipyretic activities (Patra et al., 2009a; 2009b).

Antimicrobial activity

Methanol extracts of *A. longifolia* show antimicrobial activity specially against *Burkholderia pseudomallei* strain (Samy, 2005). Petroleum ether, chloroform, alcoholic and aqueous extracts of leaves of *Hygrophila spinosa* produced significant anthelmintic activity, both alcoholic and chloroform extracts showed significant antibacterial activity as compared to other extracts (Patra et al., 2008).

Haematopoietic activity

Petroleum ether extract of root from *A. longifolia* increases WBC count significantly (Mazumdar et al., 1996). Ethanol extract (100 and 200 mg/kg, p.o.) of the aerial parts of *H. spinosa* significantly increased the haemoglobin, haematocrit, RBC and total WBC, as compared with vehicle treated control rat. In anemic male albino rats, the extract significantly increased haemoglobin, haematocrit and RBC count (Gomes et al., 2001). Petroleum ether and chloroform extract of leaves show haematopoietic activity as it significantly increases erythrocyte count, leukocyte count, and haemoglobin count (Pawar et al., 2006a; 2006b).

Antitumor

Methanol extract of seed shows inhibition of hepatocarcinogenesis in Wistar rats. Increase GPx and CAT, ODC (Ahmed et al., 2001). Petroleum ether extract from *A. longifolia* root exhibited antitumor activity in Ehrlich ascites carcinoma and Sarcoma-180 bearing mice. Extract suppressed significantly the tumor fluid volume at the end of three weeks experiment. It decreased about 50% of packed cell volume and increased life span of EAC/S-180 bearing mice in a day dependent manner. It also repressed the rapid increase of bodyweight of tumor bearing mice (Mazumdar et al., 1997). *Hygrophila spinosa* hydroalcoholic extract of aerial part could prevent or delay the development of breast cancer in the rats (Pattanayak & Sunita, 2008).

Aphrodisiac activity

The ethanolic extract of seeds shows androgenic as well as improvement of sexual behaviour of rat in dose dependent manner, it also improve the histoarchitecture of testis and increase the concentration of sperm count in epididymis and also increase testosterone level (Chauhan et al., 2009, 2010).

Phytochemical studies

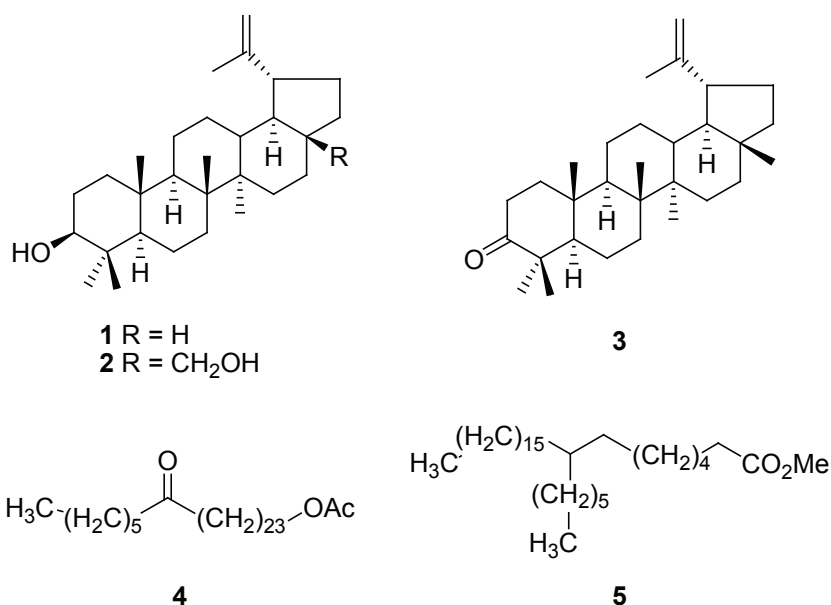
The phytochemical investigation of the *A. longifolia* as carried out so far contains various compounds with varying structural patterns. *A. longifolia* seed oil pale yellow in colour about 23% contain about 72% of linoleic, 10% of oleic, 12% of stearic, and 6% of palmitic and myristic acids (Godbole, 1941). Mineral elements Mn, Mg, Zn, Ca, Fe, Ni, Cr, Na, K, Al and Sr were found in the *A. longifolia* determined by using Flame photometer, Atomic Absorption Spectrometer and Inductively Coupled Plasma (Sondhi & Agarwal, 1995). Plant also contains minerals Fe, Cu, Co (Choudhary & Bandyopdhyay, 1998). Root contain stigmasterol (Quasim & Dutta, 1967). Aerial parts of *A. longifolia* have been reported to contain lupeol (1), stigmasterol and betulin (2) while the seeds of the plant are reported to contain mainly fatty acids (Quasim & Dutta, 1967). Petroleum ether extract of *A. longifolia* root found lupeol and lupenone (3) (Mazumdar et al., 1999). Misra et al (2001) isolated the two aliphatic esters (25-oxo-hentriacontanyl acetate 4, and methyl 8-n-hexyltetracosanoate, (5) and betulin from the aerial parts of *A. longifolia*. The HPTLC estimation of lupeol and sitosterol in various part like root, leaves, seeds and stems was reported in solvent system toluene:ethylacetate:methanol 15:3:1.5 (% v/v) (Sunita & Abhishek, 2008). The whole plant contains lupeol, stigmasterol, an isoflavone glycoside, an alkaloid and small quantities of uncharacterized bases. From the seeds isolation of sterol I, II, III, and IV, asteracanthine and asteracanthicine have been reported (Basu & Rakhit, 1957a, 1957b). Flowers contain apigenin 7-O-glucuronide (Balraj & Nagarajan, 1981; 1982). Also, amino acids histidine, lysine and phenyl-alanine have been detected in the seeds. From the plant collected from Saharanpur, lupeol, betulin and stigmasterol isolated; betulin was found to be absent in aerial parts and stigmasterol in roots (Gupta et al., 1982).

Antioxidant activity

The methanolic extract of leaves contain phenolic and flavonoid shows promising antioxidant activity (Sawadogo et al., 2006). Aqueous extract of leaves of *A. longifolia* shows potent antioxidant activity in various invitro model (Dasgupta & De, 2007).

Miscellaneous activity

Petroleum ether extract of root potentiated the sedative-hypnotic action of chlorpromazine, diazepam, pentobarbitone, chlordiazepoxide and protected against strychnine-induced convulsions (Mazumdar et al., 1999). Preliminary study shows it possess diuretic activity (Kumari & Iyer, 1967). Aqueous extract of root and leaves cure patient suffering from dropsy (Jayesingha, 1987).



Ethanollic extract of whole plant showed diuretic effects in rats (Sarfaraj Hussain et al., 2009).

Pharmacognostic studies

Plants having spines, having perennial root stocks; bluish-purple 2-lipped flower; leaves - sessile, multichambered thick-walled sclerotic cell, among the epidermal cells of midrib, large flat bunch-shaped calcium carbonate crystals and needle-shaped calcium oxalate crystals in the epidermal cells of lamina and in the cortical cells of midrib respectively; stomata-caryophyllaceous; stomatal index on upper surface: 23.46 ± 47); lower surface: 27.44 ± 52); palisade ratio: 10.23 ± 19) and vein islet number: 25.8 ± 69) (Datta & Das, 1969).

Formulation

Speman a polyherbal formulation containig *A. longifolia* improving number and morphology of sperms (Agrawal & Kulkarni, 2003).

Tissue culture

High Plant regeneration frequency in *A. longifolia* was achieved from leaf explant implanted on MS basal medium supplemented with NAA (0.5 mg/L) + BA (2.0 mg/L) through intervening callus phase. Protein and total soluble sugar contents were maximum during organogenesis and multiple shoot induction phase compared with non-organogenic callus and root induction phase. Esterase and catalase activities were maximum during organogenic differentiation, while activities were minimum at non-differentiated callus stages. Peroxidase activities were higher during rhizogenesis whereas acid

phosphatase activities were high during organogenesis and declined during rhizogenesis (Panigrahi et al., 2007).

CONCLUSION

A. longifolia has been used successfully in traditional Ayurvedic medicine for centuries, more clinical trials should be conducted to support its therapeutic use. *A. longifolia* is investigated for many pharmacological activities but still there is paucity for the mechanism and bioactive principles that are responsible for the activities.



Figure 1: View of *Asteracantha longifolia* (L.) Nees, Acanthaceae.

Further researches in view of fulfilling the need of standardization for the various constituents and extracts are desired.

ACKNOWLEDGMENT

One of the author (NSC) thanks AICTE New Delhi for providing National Doctoral fellowship.

REFERENCES

- Agrawal HSK, Kulkarni S 2003. Efficacy and safety of speman in patients with oligospermia: An open clinical study. *Indian J Clinical Practice* 14: 29-31.
- Ahmed S, Rahman A, Mathur M, Athar M, Sultana S 2001. Antitumor promoting activity of *Asteracantha longifolia* against experimental hepatocarcinogenesis in rats. *Food Chem Toxicol* 39: 19-28.
- Balraj P, Nagarajan S 1981. Apigenin 7-O-glucuronide from the flowers of *Asteracantha longifolia*. *Indian J Pharma Sci* 43: 67-68.
- Balraj P, Nagarajan S 1982. Apigenin 7-O-glucuronide from the flowers of *Asteracantha longifolia*. *Indian drugs* 19: 150-152.
- Basu N, Rakhit S 1957a. Investigation of the seeds of *Asteracantha longifolia* Nees. *Indian J Pharmacy* 19: 285-288.
- Basu NK, Rakhit S 1957b. Investigation of the seeds of *Asteracantha longifolia* Nees. *Indian J Pharmacy* 19: 282-284.
- Chauhan NS, Sharma V, Dixit VK 2009. Effect of *Asteracantha longifolia* seeds on sexual behavior of male rats. *Nat Prod Res* 14: 1-9.
- Chauhan NS, Saraf DK, Dixit VK 2010. Effect of Rasayana herbs on pituitary gonadal axis. *Europ J Integr Med* 2: 89-91.
- Chopra RN, Nayar SL, Chopra IC 1986. *Glossary of Indian Medicinal Plants*. CSIR, New Delhi.
- Choudhary BK, Bandyopdhyay 1998. Important of mineral content and medicinal properties of *Moringa oleifera* and *Hygrophila auriculata*. *Sachitra Ayurved* 50: 543-549.
- Datta PC, Das M 1969. Pharmacognostic study of root, leaf and seed of *Asteracantha longifolia* Nees. *Pharm Biol* 9: 1413-1422.
- Dasgupta N, De B 2007. Antioxidant activity of some leafy vegetables of India: A comparative study. *Food Chem* 101: 471-474.
- Fernando MR, Wickramasinghe N, Thabrew MI, Karunanayaka EH 1989. A preliminary investigation of the possible hypoglycaemic activity of *Asteracantha longifolia*. *J Ethnopharmacol* 27: 7-14.
- Fernando MR, Wickramasinghe N, Thabrew MI, Ariyananda PL, Karunanayake EH 1991. Effect of *Artocarpus heterophyllus* and *Asteracantha longifolia* on glucose tolerance in normal human subjects and in maturity-onset diabetic patients. *J Ethnopharmacol* 31: 277-282.
- Fernando MR, Wickramasinghe SMDN, Thabrew MI 1998. Extra pancreatic actions of *Hygrophila longifolia*. *Pharm Biol* 36: 352-356.
- Godbole NN, Gunde BG, Srivastava PD 1941. An investigation of oil from seed of *Hygrophila spinosa*. *Oil & Soap* 18: 206-207.
- Gomes A, Das M, Dasgupta SC 2001. Haematinic effect of *Hygrophila spinosa* T. Anderson on experimental rodents. *Indian J Exp Biol* 39: 381-382.
- Gupta DR, Bhushan R, Ahmed B, Dhiman RP 1982. Chemical examination of *Asteracantha longifolia*. *J Nat Prod* 46: 938-938.
- Gupta AK, Tandon N, Sharma M. 2006. *Quality standard of Indian Medicinal Plants*. Indian Council of Medical research, New Delhi.
- Hewawasam RP, Jayatilaka KA, Pathirana C, Mudduwa LK 2003. Protective effect of *Asteracantha longifolia* extract in mouse liver injury induced by carbon tetrachloride and paracetamol. *J Pharm Pharmacol* 55: 1413-1418.
- Jayasingha WA 1887. On *Hygrophila spinosa* (Vel *Asteracantha longifolia*). *Brit Med J*: 118-119
- Kumari GS, Iyer GY 1967. Preliminary studies on the diuretic effects of *Hygrophila spinosa* and *Tribulus terrestris*. *Indian J Med Res* 55: 714-716.
- Mazumdar UK, Gupta M, Maiti S 1996. Effect of petroleum ether extract from *Hygrophila spinosa* on hematological parameters and hepatorenal functions in mice. *Indian J Exp Biol* 34: 1201-1203.
- Mazumdar UK, Gupta M, Maiti S, Mukherjee D 1997. Antitumor activity of *Hygrophila spinosa* on Ehrlich ascites carcinoma and sarcoma-180 induced mice. *Indian J Exp Biol* 35: 473-477.
- Mazumder UK, Gupta M, Maiti S 1999. Chemical and pharmacological evaluation of *Hygrophila spinosa* root. *Indian J Pharm Sci* 61: 181-183.
- Misra TN, Singh RS, Pandey HS, Singh BK, Pandey RP 2001. Constituents of *Asteracantha longifolia*. *Fitoterapia* 72: 194-196.
- Nadkarni KM 1978. *Indian Materia Medica*, Popular Prakshan, Bombay
- Panigrahi J, Behera M, Maharana S, Mishra RR 2007. Biomolecular changes during *in vitro* organogenesis of *Asteracantha longifolia* (L.) Nees: A medicinal herb. *Indian J Exp Biol* 45: 911-919.
- Patra A, Jha S, Murthy PN, Aher VD 2008. Anthelmintic and antibacterial activities of *Hygrophila spinosa* T. Anders. *Research J Pharm and Tech* 1: 531-532.
- Patra A, Jha S, Murthy PN, Aher VD, Chattopadhyay P, Panigrahi G, Roy D 2009a. Anti-inflammatory and antipyretic activities of *Hygrophila spinosa* T. Anders leaves (Acanthaceae). *Tropical J Pharm Res* 8: 133-137.
- Patra A, Jha S, Murthy PN, Roy D, Sahu AN 2009b. Analgesic and antimotility activities of leaves of *Hygrophila spinosa* T. Anders. *Pharmacologyonline* 2: 821-828.
- Pattanayak SP, Sunita P 2008. Anti-tumor potency and toxicology of an Indian ayurvedic plant, *Hygrophila spinosa*.

- Pharmacologyonline* 2: 361-371.
- Pawar RS, Jain AP, Kashaw SK, Singhai AK 2006a. Effect of *Asteracantha longifolia* on haematological parameters in rats. *Indian J Pharmacol* 38: 285-286.
- Pawar RS, Jain AP, Kashaw SK, Singhai AK 2006b. Haematopoietic activity of *Asteracantha longifolia* on cyclophosphamide-induced bone marrow suppression. *Indian J Pharm Sci* 68: 337-340.
- Quasim C, Dutta NL 1967. Reported the presence of stigmasterol in the root of *Asteracantha longifolia* Nees. *J Indian Chem Soc* 44: 82.
- Samy RP 2005. Antimicrobial activity of some medicinal plants from India. *Fitoterapia* 76: 697-699.
- Sarfaraj Hussain MD, Nazeer Ahmed KF, Zaheen Hasan Ansari MD 2009. Preliminary studies on diuretic effect of *Hygrophila auriculata* (Schum) Heine in rats. *Int J Health Res* 2: 59-64.
- Sawadogo WR, Meda A, Lamien CE, Kiendrebeogo M, Guissou IP, Nacoulma OG 2006. Phenolic content and antioxidant activity of six Acanthaceae from Burkina Faso. *J Biol Sci* 6: 249-252.
- Shailajan S, Chandra N, Sane RT, Menon S 2005. Effect of *Asteracantha longifolia* Nees. against CCl₄ induced liver dysfunction in rat. *Indian J Exp Biol* 43: 68-75.
- Shailajan S, Chandra N, Sane RT, Menon S 2007. Effect of *Asteracantha longifolia* Nees. against galactosamine induced liver dysfunction in-rat. *Toxicol Int* 14: 7-13.
- Shivashangari KS, Ravikumar V, Devaki T 2004. Evaluation of the protective efficacy of *Asteracantha longifolia* on acetaminophen-induced liver damage in rats. *J Medicinal Food* 7: 245-251.
- Shanmugasundaram P, Venkataraman S 2005. Anti-nociceptive activity of *Hygrophila auriculata* (Schum) Heine. *Afr J Trad CAM* 2: 62- 69.
- Shanmugasundaram P, Venkataraman S 2006. Hepatoprotective and antioxidant effects of *Hygrophila auriculata* (K. Schum) Heine Acanthaceae root extract. *J Ethnopharmacol* 104: 124-128.
- Shivashangari KS, Ravikumar V, Devaki T 2004. Evaluation of the protective efficacy of *Asteracantha longifolia* on acetaminophen-induced liver damage in rats. *J Med Food* 7: 245-251.
- Singh A, Handa SS 1999. Hepatoprotective activity of *Apium graveolens* and *Hygrophila auriculata* against paracetamol and thioacetamide intoxication in rats. *J Ethnopharmacol* 49: 119-126.
- Sondhi SM, Agarwal N 1995. Determination of mineral elements in medicinal plants used for the cure of bronchitis, kidney and bladder disorder, skin diseases and gonorrhoea etc. *Hamdard Medicus* 38: 24-29.
- Sunita S, Abhishek S 2008. A comparative evaluation of phytochemical fingerprints of *Asteracantha longifolia* Nees using HPTLC. *Asian J Plant Sci* 7: 611-614.
- Thakur M, Bhargava S, Dixit VK 2007. Immunomodulatory activity of *Chlorophytum borivilianum* Sant. & F. *Evid Based Complimen Altern Med* 4: 419-423.
- The Ayurvedic Pharmacopoeia of India* 1999. Government of India, Ministry of Health and Family Welfare, Department of Indian System of Medicine & Homeopathy, New Delhi.
- Usha K, Mary Kasturi G, Hemalatha P 2007. Hepatoprotective effect of *Hygrophila spinosa* and *Cassia occidentalis* on carbon tetrachloride induced liver damage in experimental rats. *Indian J Clinical Biochem* 22: 132-135.
- Vaidya L 1970. *Bhavprakash*, Motilal banarsidas, Varanasi.
- Vijayakumar M, Govindarajan R, Rao GM, Rao CV, Shirwaikar A, Mehrotra S, Pushpangadan P 2006. Action of *Hygrophila auriculata* against streptozotocin-induced oxidative stress.