THERAPEUTIC POTENTIAL OF ERODIUM CICUTARIUM
- A REVIEW
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Abstract:
Erodium cicutarium contained tannin, catechins, gallic and elagic acids, sugars (glucose, galactose, fructose), amino acids (glycine,alanine, proline, histidine, tryptophan, tyrosine, glutamic acid), vitamins K and C. The essential oils of Erodium cicutarium contained isomenthone (11.2%), citronellol (15.4%), geraniol (16.7%) and methyl eugenol (10.6%). Erodium cicutarium possessed many pharmacological effects included antibacterial, antifungal, antiviral, interferon inducing effects, antioxidant, spasmogenic effects on uterus and diaphragmatic muscles and cardiac negative ionotropic action. The current review discussed the constituents and pharmacological effects of Erodium cicutarium.

Keywords: Erodium cicutarium, pharmacology, medicinal plants, constituents.

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INTRODUCTION:
Plants have been used as drugs by humans since thousands of years ago. As a result of accumulated experience from the past generations, today, all the world’s cultures have an extensive knowledge of herbal medicine. Traditional medicine is based on beliefs and practices that existed before the development of so-called modern medicine or scientific drug therapy. Plants are a valuable source of a wide range of secondary metabolites, which are used for treatment and prevention of the diseases [1-26]. *Erodium cicutarium* contained tannin, catechins, gallic and elagic acids, sugars (glucose, galactose, fructose), amino acids (glycine, alanine, proline, histidine, tryptophan, tyrosine, glutamic acid), vitamins K and C. The essential oils of *Erodium cicutarium* contained isomenthone (11.2%), citronellol (15.4%), geraniol (16.7%) and methyl eugenol (10.6%). *Erodium cicutarium* possessed many pharmacological effects including antibacterial, antifungal, antiviral, interferon inducing effects, antioxidant, spasmodic effects on uterus and diaphragmatic muscles and cardiac negative ionotropic action. The current review will highlight the constituents and pharmacological effects of *Erodium cicutarium*.

Synonyms:

Taxonomic classification:

Common names:
Arabic: dahmiyet el-ghazal, dardar, bakhatri; English: alfilaria, common crowfoot, common erodium, common heron’s-bill, common stork’s-bill, heron’s-bill, red-stem filaree, stork’s-bill [28].

Distribution:
*Erodium cicutarium* is distributed in Africa (Algeria, Egypt, Libya, Morocco and Tunisia); Asia (Kuwait, Iraq, Palestine, Jordan, Lebanon, Syria, Turkey, Afghanistan, Iran, Armenia, Azerbaijan, Georgia, Russian Federation, China, India, Nepal, Pakistan, Taiwan, Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan and Uzbekistan); Europe (Belarus, Estonia, Latvia, Lithuania, Moldova, Austria, Belgium, Czech, Germany, Hungary, Netherlands, Poland, Slovakia, Switzerland, Denmark, Finland, Ireland, Norway, Sweden, United Kingdom, Albania, Bulgaria, Croatia, Greece, Romania, Serbia, Slovenia, France, Portugal and Spain) and it is cultivated in South and North America [28].

Description:
Annuals 10-15(-40) cm tall. Stems numerous, erect to decumbent. Stipules triangular-lanceolate, 2-6 mm. Leaves opposite or alternate; leaf blade triangular-lanceolate to oblong-lanceolate, 5-18 cm, pinnately divided to pinnately cleft, 5-12-lobed with basal ones more deeply incised, both surfaces appressed pilose. Pedicels conspicuously longer than leaves, with (2 or)3-10 hermaphrodite flowers; peduncle with glandular and nonglandular trichomes. Pedicel 0.8-1.7 cm. Sepals ovate, 3-6 mm, glandular and hirsute, apex acute. Petals uniformly purple or 2 with a basal black spot, obovate, 5-12 mm. Mericarp 3-7 mm, with apical pit, with or without ridges or furrows; awn not plumose [30-31].
Traditional uses
The whole plant was used as astringent and haemostatic in uterine and other bleeding [32-33] and as abortifacient [34-35]. Extracts of the plant were also used in traditional medicine as anti diarrheic, diuretic, stomachic and anti hemorrhagic drugs [36]. The root and leaves were eaten by nursing mothers to increase the flow of milk. Externally, the plant has been used as a wash on animal bites and skin infections. A poultice of the chewed root was applied to sores and rashes. A tea made from the leaves was used as diaphoretic and diuretic. An infusion was used in the treatment of typhoid fever. The leaves were soaked in bath water for the treatment of rheumatism. A poultice of the seeds was applied to gouty typhus [32].

Chemical constituents:
Tannin, catechins, gallic and elagic acids, sugars (glucose, galactose, fructose), amino acids (glycine, alanine, proline, histidine, tryptophan, tyrosine, glutamic acid), vitamins K and C were identified in *Erodium cicutarium* extracts [37].

The essential oils of *Erodium cicutarium* were examined by GC/MS. The results showed that the major components were isomenthone (11.2%), citronellol (15.4%), geraniol (16.7%) and methyl eugenol (10.6%) [38].

Essential oils from entire plants and leaves and stems of *Erodium cicutarium* were obtained by hydrodistillation and analyzed by gas chromatography (GC) and gas chromatography-mass spectrometry (GC/MS). The essential oils were of a very similar chemical composition and consisted mainly of aliphatic compounds and their derivatives. Fatty acids and fatty acid derived compounds were the most common, 51.3% (entire plants) and 60.1% (leaves and stems), followed by carotenoid derived compounds, 12.6% (entire plants) and 20.2% (leaves and stems), and then terpenoids, 14.9% (entire plants) and 14.2% (leaves and stems). The main constituents in the oils were hexadecanoic acid, 22.8% (leaves and stems) and 35.9% (entire plants) and hexahydrofarnesyl acetone, 10.8% (leaves and stems) and 11.6% (entire plants) [39].

All *Erodium* species contained a small amount of volatiles (0.01–0.06 mass %). Essential oils of *Erodium cicutarium* contained fatty acids and fatty acid derived compounds: 63.8%, carotenoid derived compounds: 18.5%, terpenoids: 13.1%, monoterpenoids: 1.3%, monoterpene hydrocarbons: trace, oxygenated monoterpenes: 1.3%, sesquiterpenoids: 5.9%, sesquiterpene hydrocarbons: 0.9%, oxygenated sesquiterpenes: 5.0%, diterpenoids: 5.9% and oxygenated diterpenes: 5.9%. However, 162 compounds were identified in the essential oils of flowers, leaves, stems, and roots samples of *Erodium cicutarium*. These compounds included (%): Octane: trace, Hexanal: 0.2, Benzaldehyde: 0.1, Hexanoic acid: 0.1, 2-Pentylfuran: trace, 2,4,6-Trimethylpyridine: trace, Decane: trace, Octanal: 0.1, p-Cymene: trace, β-Phellandrene: trace, Benzyl alcohol: trace, Lavender lactone: trace, Phenyl acetaldehyde: 0.1, Heptanoic acid: trace, 1-Octanol: trace, cis-Linalool oxide (furanoid): 0.1, trans-Linalool oxide (furanoid): 0.1, 2-Nonanone : trace, p-Cymene: trace, Linalool: 0.3, Nonanal: 0.2, trans-Pinocarveol: 0.1, Camphor: 0.1, Benzoic acid: 0.5, Octanoic acid: 0.1, 1-Nonanol: 0.1, cis-Linalool oxide (pyranoid): trace, trans-Linalool oxide (pyranoid): trace, Terpinen-4-ol: 0.2, m-Cymen-8-ol: trace, p-Cymen-8-ol: 0.2, (3E)-2,6-Dimethyl-3,7-octadiene-2,6-diol: trace, 1-Dodecene: trace, Cryptone: trace, α-Terpineol: trace, Dodecane: trace, Myrtenol : trace, Decanal: 0.1, Verbenone: trace, β-Cyclocitrinal: trace, exo-2-Hydroxy-1,8-cineole: trace, Bornyl formate: trace, Phenylacetic acid: 0.1, Nonanoic acid: 0.4, 2,6-Dimethyl-1,7-octadien-3,6-diol: trace, 3-Methylundecane: trace, cis-p-Menth-2-en-1,8-diol: trace, Bornyl acetate: trace, Thymol: 0.1, Tridecane: trace, Carvacrol: trace, Undecanal: 0.1, Vinylyguajacol: trace, (E, Z)-2,4-Decadienal: trace, δ-Elemene: 0.1, Eugenol: trace, Decanoic acid: 0.1, 3-Methyldodecane: trace, Farnesane: trace, β-Bourbonene: 0.1, β-Elemene: trace, Tetradecene: 0.2, 6,10-Dimethylundecan-2-one (tetrahydrogeranyl acetone): 0.2, Dodecanal: trace, γ-Elemene: 0.3, 2,6-Dimethyl-2,6-undecadien-10-one (geranyl acetone): 0.8, 5-Methylundecane: trace, α-Humulene: trace, Homofarnesane 0.5, Undecanoic acid: trace, 1-Dodecanol: 0.1, γ-Gurjunene: trace, γ-Curcumene: trace, γ-Muurolene: 0.1, α-Curcumene: trace, Germacrene: trace, trans-β-Ionone-5,6-epoxide: 0.1, Pentadecane: 0.2, α-Muurolene: trace, Tridecanol: 0.3, Dibenzoferan: trace, γ-Cadinene: trace, 3,4-Dimethyl-5-pentyl-2(5H)-furanone (dihydrobaccoviolide): 0.1, trans-Calamenene: 0.1, Dihydroactinidiolide: 0.1, α-Calorene: 0.1, Salviodienol: trace, Dodecanoic acid: 0.3, 11-nor-Bourbonene-1-one: trace, γ-Calorene: 0.1, (Z)-3-Hexenyl benzene: trace, Spathulenol: 0.5, Caryophyllene oxide: 2.1, Hexadecane: 0.2, Viridiflorol: 0.1, Tetradeccanal: 0.4, Humuleneoxide: 0.1, nor-Copaene: 0.1, Muurola-4,10(14)-dien-1-β-ol: trace, Cubenol: 0.1, Caryophylla-4(12),8(13)-dien-5α-ol: trace, Caryophylla-4(12),8(13)-dien-5β-ol: trace, epi-α-Muurolol: 0.5, α-Muurolol: 0.1, α-Cadinol: 1.1, Tridecanoic acid: 0.1, 2-Methylhexadecane: trace, 1-Tetradecanol: trace, Cadalene: trace, Amorpha-4,9-dien-2-ol 0.3, Heptadecane: 0.2, Pristane: 0.3, 10-nor-Calamenen-10-one: trace, Pentadecane: 0.3, Methyl tetradeccanoate: trace, 4-Methylheptadecane: trace, Tetradecanoic acid: 3.5, Benzyl benzoate: 0.5, 3-Methylheptadecane: trace, 1-Pentadecane: 0.1, Phenantrene: 0.4, γ-Tridecalactone: trace, Octadecane: 0.1, Phtyane: 0.1, Hexadecanl: 0.3, Neophytadiene (isomer II): 1.1, 6,10,14-Trimethyl pentadecan-2-one.
Pharmacological effects:
Antibacterial and antifungal effects:
The essential oils of *Erodium cicutarium* were tested against Gram positive *Staphylococcus aureus* (ATCC 27853), *Staphylococcus aureus* (clinical isolate), *Clostridium perfringens* (ATCC 19404), *Bacillus subtilis* (ATCC 6633), Gram negative *Escherichia coli* (ATCC 25922), *Escherichia coli* (clinical isolate), *Klebsiella pneumoniae* (clinical isolate), *Pseudomonas aeruginosa* (ATCC 25923), and yeast *Candida albicans* (ATCC 10231). MIC of *Erodium cicutarium* against *P. aeruginosa* was 0.312 mg/ml, *Escherichia coli* (ATCC 25922) 0.625 mg/ml, *Escherichia coli* (clinical isolate) 2.5 mg/ml, *K. pneumoniae* 1.25 mg/ml, *Staphylococcus aureus* (ATCC 27853) 0.312 mg/ml, *Staphylococcus aureus* (clinical isolate) 2.5 mg/ml, *C. perfringens* 0.312 mg/ml, *B. subtilis* 0.625 mg/ml, *P. chrysogenum* 0.156 mg/ml, *A. restrictus* 0.078 mg/ml, *A. chrysogenum* 0.156 mg/ml, *A. fumigatus* 0.156 mg/ml, and *C. albicans* 0.325 mg/ml [40].

Antiviral and interferon inducing effects:
Extracts from *Erodium cicutarium* were tested for antiviral and interferon inducing properties. Both water extract and methanol extract as well as its fractions exerted antiviral effect in relation to myxoviruses, herpes virus type 1, vesicular stomatitis and vaccinia virus. None of these extracts did induce interferon in a suspension of human leukocytes [44].

Methanol extract from *Erodium cicutarium* induced interferon in a suspension of human leukocytes or in the cutaneous-muscular tissue of human embryo. It exerted stimulatory effect on the synthesis of interferon induced with Newcastle disease virus in cell cultures. The stimulation occurred irrespective of the time of methanol extract administration (before or after viral inducer). In the *in vivo* experiments, methanol extract injected intravenously induced interferon in mice. When given 24 h prior to Newcastle virus, it increased the titer of induced interferon determined in the animal serum collected 6 h after the virus injection. In the experimental viral infection in mice, the replication of influenza A virus in the lung tissue of infected animals was inhibited only when the mice were treated with methanol extract 24 and 48 h after infection with the virus [45].

Antioxidant effect:
Extracts from *Erodium cicutarium* extracts were tested for their antioxidative properties using Fe²⁺-induced triglyceride oxidation test. Hydrophobic fractions such as petroleum ether, benzene and chloroform extracts as well as hydrophilic fractions (water and ethyl acetate) possessed antioxidative effect. Tannin, catechins, gallic and elagic acids, sugars (glucose, galactose, fructose) amino acids (glycin, alanine, proline, histidine, tryptophan, tyrosine, glutamic acid), vitamins K and C were identified in *Erodium cicutarium* extracts. Standard samples of all these substances were tested for their antioxidative activity. Only polyphenolic
compounds (tannin, gallic acid, (+)-catechin and vitamin C exhibited strong antioxidantive properties [37]. Methanol extracts of nine species of geraniaceae including Erodium cicutarium were studied for their antioxidant properties using DPPH (1,1-diphenyl-2-picryl hydrazyl) radical assay. Methanol extract of Erodium cicutarium exhibited considerable free radical scavenging activity and its IC$_{50}$ values was below 50 $\mu$g/ml [46]. The methanol extract contained quercetin, kaempferol, myricetin, their mono- and di-glycosidic derivatives, and free polyphenolic acids. Low concentrations of the extract stimulated, and high concentrations inhibited, the free radical activity of human granulocytes in vitro [41].

**Effect on smooth and cardiac muscles:**
Hexane extract of Erodium cicutarium at a concentration of 0.15 mg/ml increased the tone of the guinea pig ileum preparation and reduced the strength of the contractions following field stimulation. All extracts prepared from Erodium cicutarium possessed spasmyogenic action on isolated uterus preparation of the rat. The methanol extract of Erodium cicutarium at a concentration of 1.3 mg/ml in the preparation produced regular monophasic contractions of the quiescent uterus, which ceased immediately when the tissue was washed. All extracts prepared from Erodium cicutarium increased tension in the isolated diaphragm muscle without affecting twitch strength. The addition of extracts of Erodium cicutarium to the Kreb's solution perfusing isolated heart from rabbit, they produced a negative ionotropic action. Organic extracts (hexane and methanol) showed greater activity on smooth and cardiac muscles than water extracts [34-35].

**Antiproliferative effect:**
In studying of antiproliferative effect of ethanolic extract of twenty-six plant species from the native flora used in Bolivian folk medicine, on colon cancer cells (Caco-2), the results indicated that ethanolic leaves extracts of Erodium cicutarium possessed significant antiproliferative activity. It caused 10% proliferation inhibition at 100 $\mu$g/ml [47].

**AntiiInflammatory and analgesic effects:**
A 70% ethyl alcohol thick extract from equal amounts of the aerial parts of Geranium sanguineum, Astрагalus glycyphyllos, Erodium cicutarium and Vincetoxicum officinalis was prepared to study its anti-inflammatory and analgesic effects. The anti-inflammatory effect was conducted by the method of carageenan-induced paw edema, while analgesic effect was determined by hot/cold plate and Randall & Selitto test (Algesy-meter). Rats treated with the extract at dose of (1 and 2 g/kg bw), showed no statistically significant anti-inflammatory effects. The extract also showed no reliable analgesic effect (excluding the dose of 1g/kg bw, 1$^{st}$ hour, $p = 0.031$). However, a reliable analgesic effect was recorded with the using of 2 g/kg bw of the extract on the 2$^{nd}$ and 3$^{rd}$ hour ($p = 0.037$, $p = 0.022$). In repeated dose of the extract, the treated animals showed statistically reliable analgesic effect at the dose of 1g/kg bw, on the 1$^{st}$, 2$^{nd}$ and 3$^{rd}$ hour ($p = 0.024$, $p = 0.029$, $p = 0.021$) [48].

**Other effects:**
Extracts of Erodium cicutarium of the phenolic dilactone ellagic acid inhibited the growth of the tobacco budworm, Heliothis virescens. Extracts from Erodium cicutarium plants, with paraffin oil added as an adjuvant, had some effect on controlling the Colorado potato beetle (Leptinotarsa decemlineata Say) by eliminating beetle feeding and development. The alcohol and water extracts of Erodium cicutarium possessed moderate effects in reducing body mass and caterpillar feeding of the cabbage butterfly, Pieris brassicae [49-51].

**CONCLUSION:**
This review was design to highlight the chemical constituents and pharmacological effects of Erodium cicutarium as a promising plant for many pharmacological purposes as a result of effectiveness and safety.

**REFERENCES:**
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