The cytotoxic, phytotoxic and insecticidal potential of *Senecio glaucus* L.

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Abstract

Senecio glaucus is an annual herbaceous species, erect, branched and grows in sandy soils. In the present study the cytotoxic, phytotoxic and insecticidal activities of methanolic and ethanolic extract of leaves, stem and roots of Senecio glaucus were carried out. The cytotoxic activity activity was evaluated by brine shrimp lethality bioassay while phytotoxic activity was investigated by Lemna minor bioassay. The results of cytotoxicity revealed that among all the plant parts, root methanolic extract caused maximum (90 %) mortality of brine shrimps at 1000 µg/ml. In phytotoxic activity highest (76%) inhibition of Lemna minor fronds was caused by leaves methanolic extract at 1000 µg/ml. The insecticidal activity showed that the leaves methanolic extract caused maximum mortality (97 %) of Tribolium castaneum at 1000 µg/ml. It was concluded that the plant had significant cytotoxic, phytotoxic and insecticidal potential.

Key words: Brine shrimp lethality, Lemna minor, insecticidal activity, ethanol, methanol.

Introduction

According to WHO, any plant that contains bioactive components that can be exploited for medicinal purposes is termed as a medicinal plant (Ibrahim *et al*., 2019). Recently, scientists are investigating new bioactivities from numerous medicinal plants to evolve the primary ingredients with novel curative properties against various disorders (Al-Saeedi *et al*., 2017). According to WHO, the huge percentage of the world's population relies on traditional health care system to cure different types of diseases. This kind of system of using herbal drugs possesses fewer side effects and is comparatively of low cost thus becoming the preferred system by most patients in developing countries (Ikiriza *et al*., 2019). Herbal medication is used extensively due to its efficacy, therapeutic potential and safety when compared to synthetic pharmaceuticals drugs (Kumari *et al*., 2017).

The *Senecio* genus represents the largest genus of the Asteraceae family and includes more than 1500 species of

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herbs and trees Faraone *et al.,* (2018). *Senecio* species have traditionally been utilized in folk medication for various ailments, including treatment for cough, accelerating wound healing, and as treatments for asthma and eczema Oladipupo and Adebola, (2009). In addition, several classes of various natural compounds from the *Senecio* genera have been isolated and characterized (Huang *et al*., 2008; Suleimen *et al*., 2016). Some of these classes of natural products have shown significant medicinal properties, such as antiviral, antioxidant, antifungal, antibacterial, antidiabetic, and cytotoxic properties (Steenkamp *et al.,* 2001; Christov *et al*., 2002). The selected plant has not been investigated earlier, for pharmacological study. Therefore, the current study was aimed to evaluate the cytotoxic, phytotoxic and insecticidal potential of the methanol and ethanol extract from the leaves, stems and roots of this herb.

Materials and Methods

Plant material

Senecio glaucus plants were collected from Paniala, District Dera Ismail Khan, KP in April, 2019. The collected plants were cleaned and Voucher number Ambrin Bot. 178. (PUP) was given. Leaves, stem and root were separated, washed with tap water to remove dust particles, were separately shade dried for one month and were pulverized into powder with the help of electric grinder in Pharmacognosy Lab. of University of Peshawar.

Preparation of crude extracts

The crude extracts of the leaves, stems and roots in methanol and ethanol were prepared by following the protocol of Miliauskas *et al*., (2004).

Cytotoxic activity

Cytotoxic assay of methanolic and ethanolic extract of leaves, stem and roots of *Senecio glaucus* was performed by following the protocol of Hopp *et al*., (1996).

Procedure

First, an artificial sea salt solution was prepared by dissolving 38 g of sea salt in one liter of distilled water in a hatching tray. The tray was divided into two unequal halves by perforated partition. The larger part was lit with electric lamp. The brine shrimp eggs were added to the smaller part and were allowed to stand for 48

hours at room temperature (25 ± 3 °C) for hatching (naupilii larvae). On the third day, the naupilii larvae were observed to move actively towards the illuminated side. These larvae were used for screening. Stock solution was prepared from each extract. Then stock solution was prepared by dissolving 10 mg of plant extract (soluble in water) in 1 mL of methanol and ethanol. Then from the stock solution 10, 100 and 1000 µg/ml through micro-pipette was taken in vials containing 5 ml sea salt solution and ten brine shrimps (*Artemia salina*) in each of the three replicates and was incubated for 24 hours. Survivors were counted after 24 hrs. Mortality % was calculated by following formula.

% Mortality = 100 - Number of shrimps alive in test/Total number of shrimps x 100 The data was analyzed to determine LD50 values using biostat 2006 software.

Phytotoxic activity

The methanolic and ethanolic extract of the plant parts were used for this activity using the method of Yasin *et al*., (2018).

Procedure

Five mg of the plant parts extracts were dissolved in 5 ml methanol and ethanol separately, to from each sample equivalent to 10, 100 and 1000 µg/ml. The extracts were left overnight to evaporate the solvents. E-medium was prepared from 10 particular salts with different concentrations in distillated water and volume was adjusted to 1000 ml. E-medium furnishes mineral supplementation for *Lemna minor* plants. Stock solution (10, 100 and 1000 µg/ml) was poured into the Petri dishes, to which E-medium (20 ml) and 10 plants of *Lemna minor* were added and were incubated for 7 days. Standard growth inhibitor (Paraquate) was used as negative control. After 7 days, the number of survivor fronds in each Petri dish was counted. Inhibition % was estimated as;

% inhibition = 100-Number of plants in test sample/Number of plants in -ve control x 100

Insecticidal Activity

Insecticidal assay of the plant parts extracts was carried out according to the procedure of Atta-ur-Rahman *et al*., (2001). Test insects were *Tribolium castaneum, Callosobruchnus maculatus, Sitophilus oryzae, Lasioderma serricorne* and *Oryzaephilus surinamensis*.

Table 1
Chemical composition of E-medium.

S. No	Mineral salts	Quantity (g/l)
1.	Ferric chloride (FeCl2. 4H2O)	0.00540
2.	Manganous chloride (MnCl2. 4H2O)	0.00362
3.	Magnesium sulfate (MgSO4. 7H2O)	0.492
4.	Zinc sulfate (ZnSO4. 5H2O)	0.00022
5.	Copper sulfate (CuSO4. 5H2O)	0.00022
6.	Boric acid (H3BO3)	0.00286
7.	Ethylene diamino-tetra acetic acid	0.01120
8.	Calcium nitrate (Ca (NO2)2. 4H2O)	1.180
9.	Potassium nitrate (KNO3)	1.515
10.	Potassium dihydrogen phosphate (KH2PO4)	0.68

Procedure

Filter papers were taken according to the size of petri dishes. The crude extract was dissolved in respective solvents (methanol & ethanol) to obtain stock solution. The stock solution (10, 100 and 1000 µg/ml) was overloaded on filter papers in petri dishes using micropipettes. The Petri dishes were left overnight to evaporate the solvents. Next morning, 10 healthy insects of each species were added to each petri dish including control (positive and negative) and were incubated at room temperature for 48 hrs. Three replicates were used for each extract and for control. Coopex (Hope chemical industry Islamabad) for positive control and volatile organic solvents for negative control was used. After 48 hours, the number of survivors was counted in each petri dish. Mortality % was calculated using following formula.

% Mortality = 100- (No of insects alive in test / No of insects alive in -ve control) ×100

Statistical analysis

The data was statistically analyzed to determine LD50, FI_{50} through Biostate software.

Results and Discussion

Cytotoxic activity

The results revealed that among all the plant parts, root methanolic extract caused maximum (90 %) mortality of brine shrimps followed by root ethanolic extract (87 %) at 1000 µg/ml. The minimum mortality (30 %) was caused by leaves ethanolic extract at 10µg/ml. Cytotoxicity was dose dependent as it increased with the

increase of extract concentration. Based on the LD50 value, it was noted that stem methanolic extract showed maximum cytotoxicity against shrimps and showed (LD50=1.05 µg/ml) (Table 2 & Fig. 1).

Many other workers performed brine shrimp lethality assay for evaluating medicinal stems, and the results agree with the present findings including (*Ageratum conyzoides*, Nasrin, 2013; *Stachytarpheta jamaicensis*, Widiyastuti *et al.*, 2019) as far as the LD_{50} is concerned (Table 2). The potential of the extracts was attributed to the presence of alkaloids. According to Bonea *et al.* (2017) alkaloids (57 %) detected in the extracts caused in the mitotic depression of brine shrimps. That is the main cause of the drastic reduction of growth and development. Sousa & Viccini (2011) explained the reduction of mitotic index as a result of the interphase nuclear division, thus stopping the onset of prophase, and thus the cell division in shrimps. Zimudzi *et al*. (2012) and Khurm *et al*. (2016) reported the similar mechanism. Cytotoxicity personifies a rapid, inexpensive and easy bioassay for testing plant extracts bioactivity such as pesticidal, antifilarial, antimalarial, antiplasmodial and anti-tumor properties (Afagnigni *et al*., 2020).

Based on these results, it is suggested that this specie can be used as new sources of natural and potential anticancer compounds as well as pesticidal, ant filarial, antimalarial and antiplasmodial agent.

Phytotoxic activity

The phytotoxic screening of leaves, stem and roots using the methanolic and ethanolic extracts caused the inhibition of *Lemna minor* fronds and it revealed that the phytotoxic activity was dose dependant, it increased with the increase in extract concentration. It was observed that significant toxic effect was shown by the leaves methanolic extract and caused (76 %) inhibition of *Lemna minor* fronds followed by (72 %) by stem methanolic extract at 1000 µg/ml. The minimum inhibition (53 %) of *L. minor* was caused by root methanolic and ethanolic extracts at 10 µg/ml. Based on FI50 value, it was concluded that the leaves methanolic extract showed significant frond inhibitory effects (FI50 value=0.10 µg/ml) (Table 3 & Fig. 2).

Other investigators also reported the phytotoxic effects of many medicinal leaves and stem and it is in line with the present work. Few examples (*Acalypha torta*, Onocha *et al*., 2011; *Apium graveolens*, Sbai *et al*., 2017; *Hyptis suaveolens*, Sharma *et al.*, 2019) as far as the FI50 was concerned (Table 3 & Fig. 2). Phytotoxicity might be due to the presence of phenolic compounds and tannins which were detected in these extracts (Jadhav *et al*., 2011; Magdich

et al., 2012). Phenolic compounds (highly chemically reactive) may influence the absorption of nutrients by the roots, suppressing the growth of the herbs and weeds. These compounds modify the permeability of the cell membrane, the protein synthesis, enzymatic activity, hormone synthesis and the photosynthesis, accordingly inhibiting the normal *Lemna* growth (Aragao *et al.*, 2017).

Tannins lead to cell death of *Lemna*. Chromatin condensation as well as cytoplasmic shrinkage are morphological features of programmed cell death in plants (Santos *et al.*, 2019). Bali *et al*. (2017) and Martino *et al.* (2010) also reported similar mechanism of action of these compounds. The use of various, environmentally friendly scheme for pest management is one of the authentications of organic farming systems, where weed control is considered to be one of the major contests. Plant substances with allelopathic positive response may function as basis for natural weed control, giving rise to natural bioherbicides with lower environmental impacts (Santos *et al*., 2019).

Table 2
Cytotoxic activity of Senecio glaucus

Plant part	Extracts	Dose (2)	Total No. of larvae	No. of alive larvae	No. of dead Larvae	% mortality	LD_{50} (µg/ml)
	Control		30	30	0		
		10	30	16	14	46.60	
	Methanol	100	30	11	19	63.33	17
		1000	30	07	23	77	
Leaves		10	30	21	9	30	
	Ethanol	100	30	17	13	43.30	782
		1000	30	15	15	50	
		10	30	12	18	60	
	Methanol	100	30	10	20	67	1.05
		1000	30	7	23	77	
Stem		10	30	15	15	50	
	Ethanol	100	30	12	18	60	11.36
		1000	30	8	22	73.30	
		10	30	11	19	63.33	
Root	Methanol	100	30	5	25	83	2.0
		1000	30	3	27	90	
		10	30	12	18	60	
	Ethanol	100	30	9	21	70	3.27
		1000	30	4	26	87	

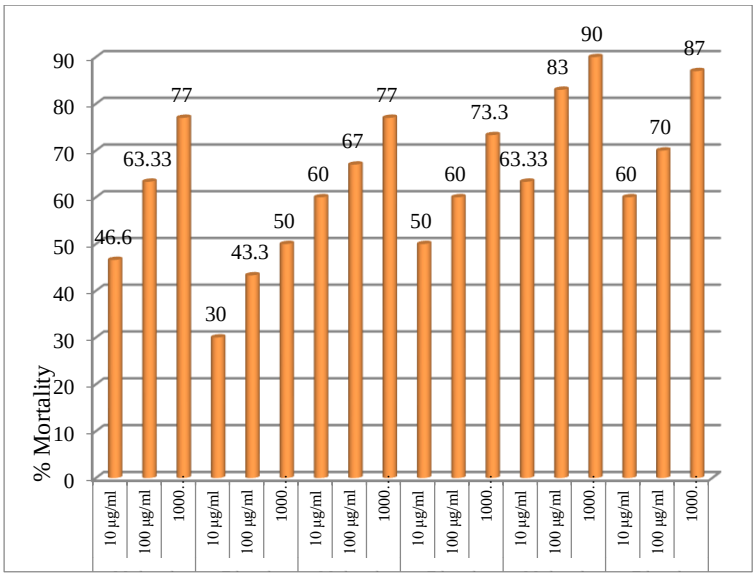

Fig. 1. Cytotoxic activity of Senecio glaucus

Table 3
Phytotoxic activity of Senecio glaucus

Plant part	Extracts	Dose (µg/ml)	No. of fronds in test	No. of fronds in -ve control	% inhibition	FI_{50} (µg/ml)
Leaves	Methanol	10	33	92	64	0.10
		100	29		68	
		1000	22		76	
	Ethanol	10	38	92	57	0.39
		100	31		66	
		1000	29		68	
Stem	Methanol	10	37	92	60	0.33
		100	32		65	
		1000	26		72	
	Ethanol	10	41	92	55	2.28
		100	34		63.04	
		1000	28		70	
Root	Methanol	10	43	92	53	7.0
		100	39		58	
		1000	27		71	
	Ethanol	10	43	92	53	5.0
		100	35		62	
		1000	28		70	

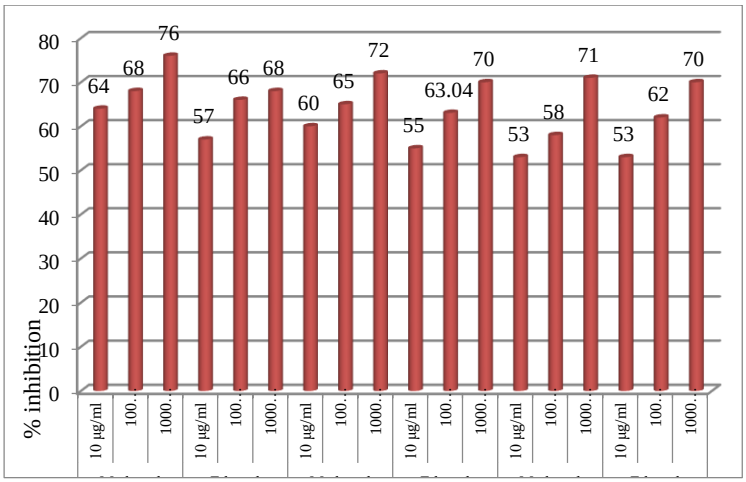

Fig. 2. Phytotoxic activity of Senecio glaucus Insecticidal activity

The above results revealed that *Senecio glaucus* possessed significant growth inhibitory effects supporting its phytotoxic potential, herbicidal and weed-suppressing potential. Results showed that various plant parts had insecticidal potential. Effects were dose dependent as there was an increase in the percent mortality of test insects with the increase of extract concentration. The results revealed that the leaves methanolic extract caused maximum mortality (97 %) of *Tribolium castaneum* at 1000 µg/ml followed by (93 %) at 100 µg/ml. The minimum mortality (23 %) of *Tribolium castaneum* and *Callosobruchnus maculatus* was caused by stem ethanolic extract at 10 µg/ml. Based on LD_{50} value, it was concluded that among all the plant parts extracts, the lowest LD50 value (0.009 µg/ml) was shown by leaves methanolic extract against *Tribolium castaneum.* Hence, leaves had more significant insecticidal effects followed by root and stem i.e., leaves > root > stem (Table 4a-c & Fig. 3a-c). Further, bioassay revealed that *Tribolium castaneum* was the most susceptible insect in the experiment i.e., *Tribolium castaneum* > *Sitophilus oryzea* > *Callosobruchnus maculatus* > *Oryzaephilus surinamensis* > *Lasioderma serricorne.*

Many researchers reported the insecticidal activity of leaves of various medicinal herbs, the results are in line with the present findings. Mahama *et al.* (2017); Halimatussakdiah *et al.* (2018) studied the insecticidal activity of *Cassia mimosoides* and *Diplazium esculentum* leaves, respectively and reported the similar insecticidal effects. Alloun *et al.* (2019) showed that the extracts were more toxic against *Tribolium*

castaneum and the toxicity herein observed might be explained by the presence of bioactive compounds. The toxic (insecticidal) effects would be due to the presence of saponins (60 %), carbohydrates and fixed oil detected in the extracts. These metabolites lead to several physiological disruptions such as acetyl cholinesterase inhibition, Na and K exchange disturbance, inhibition of cellular respiration, obstruction in calcium channels and holdup of morphogenesis and thus leads to lethality (Mungenge *et al*., 2014; Vinayaka *et al.*, 2009; Udebuani *et al*., 2015). In addition to abiotic factors, biotic changes are also equally responsible for the physiological, behavioral and morphological adaptations in the insects along with its population fluctuation. Both abiotic (temperature, humidity, light, chemicals, pollutants, gaseous effect, Immune genetic responses) and biotic stresses significantly influence the insects (Khaliq *et al*., 2014). Insecticidal effects of plant extracts vary not only according to plant species and age, mosquito species, and geographical varieties but also due to solvents used during extraction (Cui *et al.,* 2020). Compared to synthetic drugs, natural insecticides are less detrimental to human health and environment, and so they are extensively recognized by the general population. Hence, it is necessary to assess the insecticidal potential of essential oils or plant extracts in order to determine their promise as insecticides (Riosa *et al*., 2017). The current discussion revealed that the selected plant is a good insecticidal agent.

Conclusion

The methanolic and ethanolic extract from leaves, stems and roots of *Senecio glaucus* has great cytotoxic, phytotoxic and insecticidal effect. Therefore, it is recommended that *Senecio glaucus* could serve as a natural anticancer, herbicidal and insecticidal drug and the effects could be attributed to the presence of various bioactive compounds. Further research could be done to evolve it as an alternative to synthetic herbicides and insecticides in sustainable agricultural system under field conditions.

Table 4a
Insecticidal activity of leaves of Senecio glaucus

Test insects	Leaves	Dose (µg/ml)	No. of insects in - ve control	No. of insects alive	No. of dead insects	% mortality	LD_{50} (µg/ml)
Tribolium castaneum (Herbst, 1797)	Methanol	10	30	3	27	87	0.009
		100	30	2	28	93	
		1000	30	1	29	97	
	Ethanol	10	30	15	15	50	8.23
		100	30	11	19	63	
		1000	30	9	21	70	
Sitophilus oryzea (Linnaeus, 1763)	Methanol	10	30	9	21	70	0.48
		100	30	7	23	77	
		1000	30	3	27	90	
	Ethanol	10	30	15	15	50	6.73
		100	30	12	18	60	
		1000	30	11	19	63	
Callosobruchnus Maculatus (Fabricius, 1775)	Methanol	10	30	8	22	73	0.03
		100	30	5	25	83	
		1000	30	3	27	87	
	Ethanol	10	30	16	14	47	28.62
		100	30	14	16	53	
		1000	30	11	19	63	
Oryzaephilus surinamensis (Linnaeus, 1758)	Methanol	10	30	10	20	67	0.37
		100	30	6	24	80	
		1000	30	4	26	86	
	Ethanol	10	30	17	13	43	49.81
		100	30	14	16	53	
		1000	30	11	19	63	
Lasioderma Serricorne (Fabricius, 1792)	Methanol	10	30	10	20	67	0.435
		100	30	7	23	77	
		1000	30	4	26	86	
	Ethanol	10	30	18	12	40	58.28
		100	30	13	17	57	
		1000	30	12	18	60	

Table 4b
Insecticidal activity of stem of Senecio glaucus

Test insects	Stem	Dose (µg/ml)	No. of insects in - ve control	No. of insects alive	No. of dead insects	% Mortality	LD_{50} (µg/ml)
Tribolium castaneum (Herbst, 1797)	Methanol	10	30	13	17	57	4.33
		100	30	10	20	67	
		1000	30	5	25	83	
	Ethanol	10	30	23	7	23	1,435.76
		100	30	19	11	37	
		1000	30	16	14	47	
Sitophilus oryzea (Linnaeus, 1763)	Methanol	10	30	14	16	53	4.91
		100	30	8	22	73	
		1000	30	6	24	80	
	Ethanol	10	30	19	11	37	3,293.63
		100	30	17	13	43	
		1000	30	16	14	47	
Callosobruchnus Maculatus (Fabricius, 1775)	Methanol	10	30	14	16	53	8.02
		100	30	11	19	63	
		1000	30	6	24	80	
	Ethanol	10	30	23	7	23	9,509.33
		100	30	20	10	33	
		1000	30	18	12	40	
Oryzaephilus surinamensis (Linnaeus, 1758)	Methanol	10	30	14	16	53	3.32
		100	30	9	21	70	
		1000	30	8	22	73	
	Ethanol	10	30	22	8	27	198,121.79
		100	30	20	10	33	
		1000	30	19	11	37	
Lasioderma Serricorne (Fabricius, 1792)	Methanol	10	30	14	16	53	6.95
		100	30	13	17	57	
		1000	30	9	21	70	
	Ethanol	10	30	19	11	37	184,349.51
		100	30	18	12	40	
		1000	30	17	13	43	

Table 4c
Insecticidal activity of root of Senecio glaucus

Test insects	Root	Dose (µg/ml)	No. of insects in - ve control	No. of insects alive	No. of dead insects	% mortality	LD_{50} (µg/ml)
Tribolium castaneum (Herbst, 1797)	Methanol	10	30	9	21	70	0.12
		100	30	6	24	80	
		1000	30	6	26	86	
	Ethanol	10	30	19	11	37	122.6
		100	30	15	15	50	
		1000	30	12	18	60	
Sitophilus oryzea (Linnaeus, 1763)	Methanol	10	30	10	20	67	0.02
		100	30	8	22	73	
		1000	30	3	27	87	
	Ethanol	10	30	18	12	40	171.56
		100	30	17	13	43	
		1000	30	12	18	60	
Callosobruchnus Maculatus (Fabricius, 1775)	Methanol	10	30	12	18	60	2.16
		100	30	9	21	70	
		1000	30	5	25	83	
	Ethanol	10	30	18	12	40	172.46
		100	30	16	14	47	
		1000	30	13	17	57	
Oryzaephilus surinamensis (Linnaeus, 1758)	Methanol	10	30	13	17	57	2.43
		100	30	8	22	73	
		1000	30	6	24	80	
	Ethanol	10	30	20	10	33	501.36
		100	30	17	13	43	
		1000	30	14	16	53	
Lasioderma Serricorne (Fabricius, 1792)	Methanol	10	30	12	18	60	0.37
		100	30	10	20	67	
		1000	30	8	22	73	
	Ethanol	10	30	20	10	33	605.53
		100	30	16	14	47	
		1000	30	15	15	50	

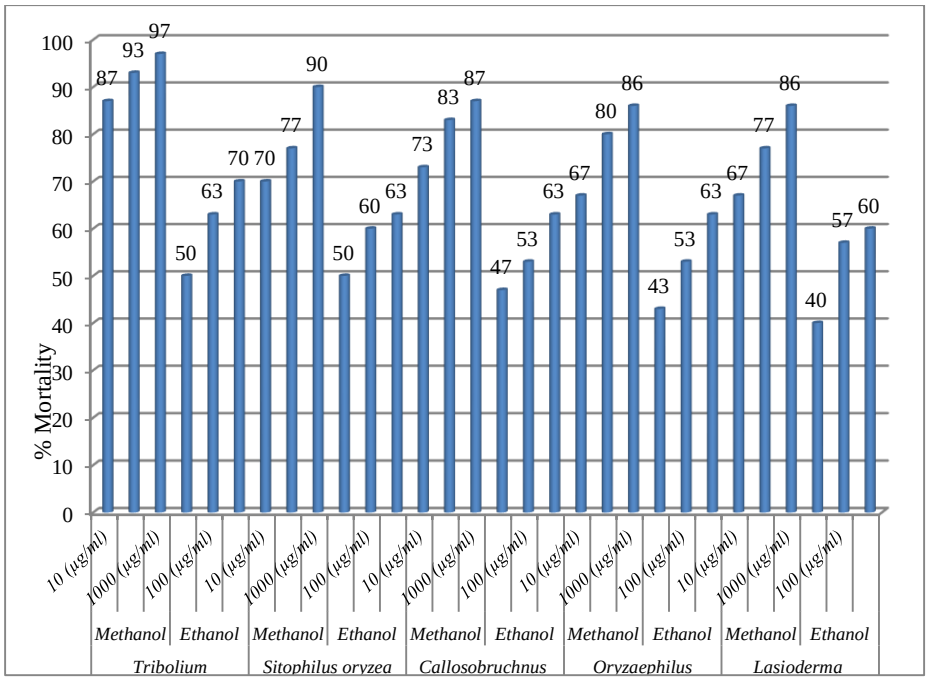

Fig. 3a. Insecticidal activity of leaves of Senecio glaucus

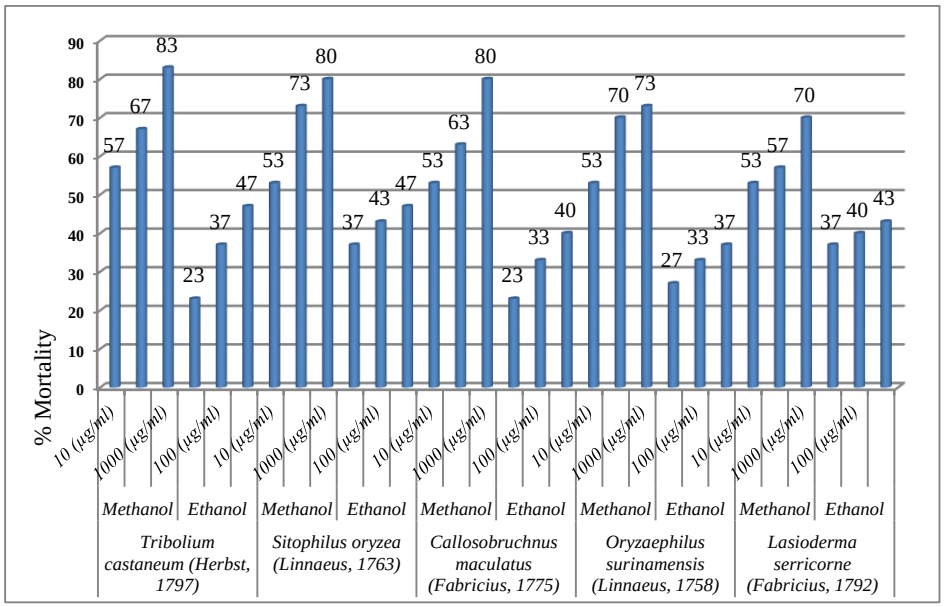

Fig. 3b. Insecticidal activity of stem of Senecio glaucus

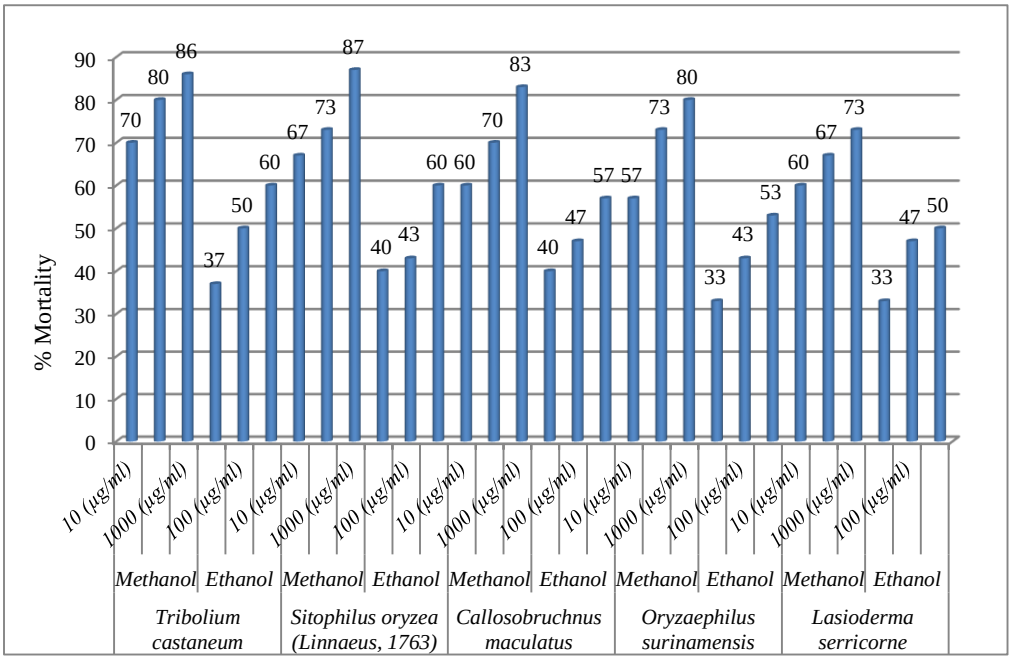

Fig. 3c. Insecticidal activity of root of Senecio glaucus

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