



Available Online at EScience Press

Plant Protection

ISSN: 2617-1287 (Online), 2617-1279 (Print)

<http://esciencepress.net/journals/PP>

Research Article

SEASONAL OCCURRENCE OF THE BROAD MITE, *POLYPHAGOTARSONEMUS LATUS* (BANKS), ON ROSELLE AND ITS CONTROL USING BOTANICAL EXTRACTS

Hala Kadhem Jbir Al-Jubouri, Shaymaa A.K. Al-Hamawandy, Lara B. Yasir

Department of Plant Protection, College of Agricultural Engineering Sciences, University of Baghdad, Iraq.

ARTICLE INFO

Article history

Received: 22nd February, 2025Revised: 17th May, 2025Accepted: 31st May, 2025

Keywords

Broad mite

Polyphagotarsonemus latus

Roselle

Seasonal occurrence

Botanical extracts

ABSTRACT

The broad mite (*Polyphagotarsonemus latus* (Banks); Acari: Tarsonemidae) is a significant pest affecting a variety of host plants, particularly the yellow and dark red cultivars of *Hibiscus sabdariffa* (roselle), causing considerable economic losses. The present study, conducted from September 15, 2022, to April 12, 2023, at the Department of Plant Protection, University of Baghdad, evaluated the impact of the pest and assessed the efficacy of both alcoholic and aqueous extracts from *Nerium oleander*, *Eucalyptus* spp., and *Mentha* spp. in managing the mite. Laboratory assays showed that all tested extracts, at concentrations of 10, 20, and 30 mg/ml, effectively suppressed various developmental stages of the mite, with oleander extract causing the highest mortality rates, followed by eucalyptus and mint extracts. Notably, larvae experienced the greatest mortality after seven days, while eggs were the least susceptible. Field observations revealed the continuous presence of the mite population on roselle cultivars over six months, with higher infestation levels recorded on the yellow cultivar compared to the dark red. Population density analysis indicated greater numbers of eggs, larvae, nymphs, and adults on the yellow cultivar, with two distinct seasonal peaks, one in late November (autumn) and another in early April (spring). Among the botanical treatments, alcoholic oleander extract was the most effective, followed by eucalyptus and mint extracts, whereas the aqueous mint extract showed comparatively lower control efficacy. Based on the findings, the use of alcoholic *N. oleander* extract is recommended as the most effective botanical treatment for managing broad mite infestations in roselle.

Corresponding Author: Hala Kadhem Jbir Al-Jubouri

Email: hala.kadhem1004@coagri.uobaghdad.edu.iq

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INTRODUCTION

Roselle (*Hibiscus sabdariffa* L.), a member of the Malvaceae family, is globally valued for its medicinal, nutritional, and industrial applications, with significant economic importance rooted in tropical Africa. Its cultivation has since spread to numerous countries, including India, Saudi Arabia, Malaysia, Thailand, Vietnam,

Egypt, Sudan, Mali, Mexico, and China (Toukara et al., 2011; Al-Hasan, 2012; Kadhim, 2022). In Iraq, it is known by various names such as “karkadeh”, “red tea” and “Mecca tea” while in Egypt and Sudan, “karkadeh” is the predominant term (Al-Hasan and Najeeb, 2011). The plant’s economic and therapeutic value derives from its seeds, leaves, and calyces, which are used in the

pharmaceutical, food, and textile industries to produce items such as juices, jams, oils, and beverages.

Rich in antioxidants like anthocyanins and protocatechuic acid, roselle contributes to health by reducing oxidative stress and lipid peroxidation (Ali et al., 2005; Abou-Arab et al., 2011; Al-Khateeb, 2016; Hashem et al., 2017; Al-Mayahi and Hassan, 2023; Al-Hamawandy et al., 2024). Due to its medicinal properties, roselle has traditionally been used to treat ailments such as hypertension, liver disorders, fever, urinary tract infections, uterine and intestinal muscle pain, arteriosclerosis, and digestive problems (Yang et al., 2019; Jaddoa and Gharb, 2021; Dibeem, 2022). Botanically, it is an annual shrub reaching 1-2.5 meters in height, characterized by red or green stems, axillary red flowers, lobed leaves, and calyces rich in calcium and sodium. Its seeds contain 20-24% fixed oil, which is comparable in quality to cottonseed oil (Ansari et al., 2013).

Roselle is threatened by pests such as the broad mite (*Polyphagotarsonemus latus*), also known as the yellow or tropical mite. This pest is a major concern in both open-field and greenhouse cultivation in tropical and subtropical regions. It attacks more than 60 plant families, including economically important crops such as pepper, tomato, potato, okra, and tea, as well as ornamental plants like African violets, chrysanthemums, cyclamen, dahlias, hibiscus, and ivy (Kamruzzaman et al., 2013; Navasero et al., 2015; Malik and Hermize, 2020; Al-Azzazy and Saleh, 2018; Al-Dahwi et al., 2023).

In response, there is growing interest in environmentally friendly, plant-based pest control strategies (Monteiro et al., 2015; Yousif and Hassan, 2023; Swari and Aziz, 2024). Botanical extracts are increasingly preferred due to their low toxicity, biodegradability, and broad spectrum of bioactivity. These extracts function in various roles, including acting as toxins, behavior modifiers, oviposition deterrents, and reproductive inhibitors, making them sustainable alternatives for integrated pest management, especially in protected cultivation systems.

In Iraq, promising plant species for broad mite control include oleander (*Nerium oleander*), eucalyptus (*Eucalyptus* spp.), and spearmint (*Mentha spicata*), all of which contain compounds known for their pest-repelling and toxic effects (Theurkar et al., 2014; Malik, 2020; Al-Jboori and Al-Dahwi, 2020).

The primary aim of this research was to identify effective plant-based strategies for managing broad mite

infestations, a pest of high economic significance that is difficult to detect due to its minute size and remains poorly understood in terms of its biology and ecology. To achieve this, the study focused on two main objectives: estimating the population density of the broad mite and evaluating the efficacy of alcoholic and aqueous extracts of oleander (*Nerium oleander*), eucalyptus (*Eucalyptus* spp.), and spearmint (*Mentha spicata*) at concentrations of 10, 20, and 30 mg/ml for controlling this pest species.

MATERIALS AND METHODS

Identification

Broad mite samples were collected from roselle plants, mounted in Hoyer's medium, and identified based on genus- and species-level diagnostic traits following Krantz and Walter (2009).

Preparation of plant extracts

Plant extracts were prepared using the method described by Harborne (1973) and Khanzada et al. (2006). Dried plant parts were ground into a fine powder using an electric grinder and sieved through a 50-mesh sieve. The powder was soaked in either distilled water for aqueous extraction or 70% ethanol for alcoholic extraction. For extraction, 20 g of plant powder was mixed with 100 ml of the respective solvent (1:5 ratio). The mixture was stirred on a magnetic stirrer for 24 h at 40°C. It was then filtered through several layers of medical gauze and subsequently through Whatman No. 1 filter paper. The filtrate was centrifuged at 2500 rpm for 10 min. The clear supernatant was poured into sterile glass Petri dishes and incubated at 40°C for 2-3 days until dry. The dried extract was scraped using a sterile blade, weighed, and stored in airtight, clean plastic containers for later use. This yielded the dry aqueous or alcoholic extracts. The entire process was conducted in the central laboratory of the College of Agricultural Engineering Sciences, University of Baghdad.

Evaluation of the bioefficacy of alcoholic extracts of oleander, eucalyptus, and mint on different life stages of the broad mite under laboratory conditions

The study evaluated the effects of alcoholic extracts of oleander, eucalyptus, and mint at concentrations of 10, 20, and 30 mg/ml on various life stages of the broad mite, with each stage treated separately for each extract. A total of 252 transparent plastic dishes were prepared, divided equally among the three extracts (84 dishes per extract). Each dish was lined with moistened medical cotton and leaf discs from the most susceptible roselle cultivar (yellow) were placed with their undersides in contact with the cotton.

The dishes were divided into four groups: 20 eggs, 20 larvae, 20 nymphs, and 20 adults. Eggs and individuals were carefully placed on the leaves using a microscope, with excess removed using a fine needle. Each group contained 12 dishes, with three replicates per concentration. Nine dishes per group were treated with the extracts at the specified concentrations. The control treatment involved spraying with water only.

Each dish received 0.5 mL of extract using a hand sprayer. After spraying, dishes were left uncovered for 1 h to dry, then placed in an incubator at $25 \pm 2^\circ\text{C}$, with 50-60% relative humidity and a 12-h photoperiod. Leaf discs were replaced as needed. Mortality was recorded at 1, 3, 5, and 7 days post-treatment. Mortality was confirmed through observable morphological changes, such as egg shrinkage and discoloration. Mortality percentages were corrected using the modified Abbott's formula (Abbott, 1925), also referred to as the Schneider and Orell formula (Shaaban and Al-Mallah, 1993).

The experiment was repeated using aqueous extracts of oleander, eucalyptus, and mint at the same concentrations, and mortality was similarly recorded at 1, 3, 5, and 7 days post-treatment.

Estimation of population density of broad mite life stages and susceptibility of roselle cultivars to infestation

This study was conducted in a lath house under the supervision of the Plant Protection Department, College of Agricultural Engineering Sciences, University of Baghdad, Al-Jadriya. The structure covered an area of 48 m² (12 × 4 m) and had a height of 3.5 m. The soil was prepared for planting, and the experiment was laid out in a randomized complete block design (RCBD) with three blocks spaced 1 m apart.

Two local roselle cultivars, dark red and yellow, were transplanted into the experimental field. Saplings were grown in 15 cm diameter black polyethylene bags containing a 1:1 loamy soil and peat moss mixture. The one-month-old, uniform saplings were managed using standard agronomic practices. The lath house was divided into two sections. In the first section (3 m in length), three replicates were established with random allocation of the two cultivars within each block. Each block consisted of two experimental units (1 m² each), with six saplings per unit planted 40 cm apart. Each unit was labeled for cultivar identification.

This section was used to assess the population density and susceptibility of the two cultivars to infestation by

the broad mite. Agronomic practices such as irrigation, fertilization, and weeding were conducted according to roselle cultivation guidelines.

Sampling was conducted every 10 days by collecting six leaves per experimental unit, totaling 18 leaves per cultivar and 36 leaves overall. The leaves were placed in labeled nylon bags, transported to the laboratory, and examined microscopically to count eggs, larvae, nymphs, and adults. Population density was calculated as the average number of mites per leaf. The study spanned from September 15, 2022, to April 12, 2023.

Evaluation of the efficacy of alcoholic and aqueous extracts of oleander, eucalyptus, and mint in controlling broad mite under field conditions

A field experiment was conducted in the second section of the lath house using RCBD with three blocks to evaluate the efficacy of plant extracts in controlling *P. latus*. The total experimental area was 27 m². Each block had seven experimental units (1 m² each), and a total of 126 yellow roselle saplings were planted (six per unit). All agricultural practices were applied according to standard guidelines.

Treatments were randomly assigned to units and included:

1. Alcoholic extract of oleander (30 mg/ml),
2. Alcoholic extract of eucalyptus (30 mg/ml),
3. Alcoholic extract of mint (30 mg/ml),
4. Aqueous extract of oleander (30 mg/ml),
5. Aqueous extract of eucalyptus (30 mg/ml),
6. Aqueous extract of mint (30 mg/ml) and
7. Control (water only)

Spraying was conducted on August 2, 2023, using separate, calibrated 2-liter hand sprayers for each treatment to avoid cross-contamination. Nylon barriers were used to isolate each unit and minimize spray drift. Sampling was performed one day before treatment and at 1, 3, 7, 10, 14, and 21 days post-treatment. For each sampling, 10 leaves per experimental unit were collected, totaling 30 leaves per treatment and 210 leaves in total. Samples were analyzed microscopically to determine the number of mite stages per leaf.

The effectiveness and persistence of each treatment were assessed by calculating mite population density and evaluating control efficacy using the formula of Henderson and Tilton (1955).

Statistical analysis

Data were analyzed according to the experimental design employed. Laboratory experiments followed a completely

randomized design, while field experiments used a randomized complete block design. Data were subjected to analysis of variance (ANOVA), and mean differences were compared using the Least Significant Difference (LSD) test at a 0.05 probability level, as outlined by Al-Rawi and Khalaf-Allah (2000). All statistical analyses were performed using Genstat software.

RESULTS AND DISCUSSION

Identification

The diagnostic results indicated that the mites mounted on glass slides were identified as developmental stages of the broad mite, based on specialized scientific references and online resources. The identification was carried out using the diagnostic characteristics of the genus and species, following the taxonomic key provided by Krantz and Walter (2009).

Microscopic analysis and morphology of the broad mite

Microscopic analysis at 100× magnification revealed distinct morphological features of the mite. The adult female was larger than the male, with a semi-circular body approximately 0.22 mm long and 0.12 mm wide. A prominent white dorsal line divided the dorsal surface into two halves and branches near the posterior end. The abdomen was narrower than the rest of the body. The fourth legs were cylindrical with a long terminal hair on the tarsus. Females exhibited rapid movement and voracious feeding behavior, with a lifespan of 10-14 days. They laid 2-4 eggs daily, singly, on the underside of leaves. Male mites were smaller, about 0.11 mm long, with a short, broad anterior tapering posteriorly, and were brown in color. They possessed a sucker at the end of the abdomen and long third legs. The fourth legs were shorter and thicker, also bearing a long terminal hair, which aided in lifting the female pupa onto the abdominal sucker during copulation. Males were typically found near female pupae, positioning themselves for mating, which lasted 15-20 sec. Their lifespan was shorter, ranging from 5-9 days.

Eggs were small, oval, about 0.07 mm long and 0.05 mm wide, transparent, and covered with visible white warts. They were laid in 5-6 rows on the leaf surface. Upon hatching, white, pear-shaped larvae emerged, with the rear end narrower than the front. Larvae had three pairs of legs and a characteristic white dorsal stripe. Male larvae were smaller (about 0.012 mm long and 0.06 mm wide), tapering at the rear, while female larvae were

larger (approximately 0.14 mm long and 0.078 mm wide) and oval-shaped. The larval stage included a single phase before transforming into the nymph stage.

During the nymph stage, the mite became immobile, attaching to the leaf surface. Nymphs were pear-shaped, slightly larger than larvae (about 0.2 mm long and 0.1 mm wide), with distinctive markings at both ends. They were non-feeding and typically resided in leaf depressions. These observations are consistent with the findings of Krantz and Walter (2009), Abhishek (2015), Shukla and Radadia (2018), Malik and Hermize (2020), Ovando-Garay et al. (2022), and Rashid et al. (2024).

Bioevaluation of alcoholic extracts of oleander, eucalyptus, and mint on broad mite stages under laboratory conditions

Alcoholic extracts of oleander, eucalyptus, and mint, tested at concentrations of 10, 20, and 30 mg/ml, were effective against various life stages of the broad mite. As shown in Table 1, the oleander extract had the highest mortality effect, followed by eucalyptus, while mint showed the lowest efficacy across all concentrations.

Mortality rates increased significantly with higher concentrations. After seven days, the corrected mortality of eggs was highest for oleander extract at 44.84%, 63.87%, and 65.80% for 10, 20, and 30 mg/ml, respectively. Eucalyptus followed with 42.96%, 60.79%, and 63.43%, while mint recorded 41.23%, 58.64%, and 62.00%.

For larvae, mortality rates after seven days were 49.04%, 69.42%, and 81.67% for oleander; 47.25%, 67.13%, and 76.56% for eucalyptus; and 45.61%, 64.70%, and 74.02% for mint.

For nymphs, mortality was 46.72%, 65.65%, and 76.30% (oleander); 44.33%, 63.85%, and 71.52% (eucalyptus); and 42.31%, 61.50%, and 69.41% (mint).

In adults, the rates were 48.13%, 67.73%, and 79.64% (oleander); 45.84%, 65.32%, and 73.81% (eucalyptus); and 44.30%, 63.34%, and 71.95% (mint).

Over time, mortality rates increased progressively, showing a positive correlation with both concentration and exposure duration. For example, egg mortality after one day was 13.83% (oleander), 12.02% (eucalyptus), and 10.57% (mint), increasing after seven days to 87.48%, 85.14%, and 83.00%, respectively. In larvae, mortality increased from 27.38%, 24.27%, and 21.94% (after one day) to 93.15%, 90.86%, and 88.95% (after seven days) for oleander, eucalyptus, and mint, respectively.

Table 1. Bioevaluation of the efficacy of alcoholic extracts from oleander, eucalyptus, and mint leaves on the percentage mortality of different developmental stages of *P. latus* under laboratory conditions.

Treatment	Concentration	Corrected percentage mortality of <i>P. latus</i> at different days after treatment with alcoholic extracts of leaves of																		
		Oleander					Eucalyptus					Mint								
		1	3	5	7	Mean	1	3	5	7	Mean	1	3	5	7	Mean				
Egg	10	10.62	38.90	47.75	82.10	44.84	9.42	35.91	46.40	80.12	42.96	8.31	34.75	43.22	78.62	41.23				
	20	14.60	65.98	85.57	89.33	63.87	12.40	62.68	82.46	85.62	60.79	10.38	60.68	80.15	83.33	58.64				
	30	16.27	68.14	87.80	91.00	65.80	14.23	64.09	85.72	89.67	63.43	13.03	63.13	84.79	87.04	62.00				
	Mean	13.83	57.67	73.71	87.48	58.17	12.02	54.23	71.53	85.14	55.73	10.57	52.85	69.39	83.00	53.95				
	LSD at 0.05	Treatment (a) = 1.10					Concentration (b) = 1.10					days (c) = 1.23					Interaction (a × b × c) = 1.53			
Larvae	10	16.42	41.17	52.44	86.11	49.04	14.52	39.67	51.13	83.67	47.25	13.02	37.62	49.33	82.45	45.61				
	20	23.86	70.84	89.66	93.33	69.42	21.62	69.33	86.66	90.91	67.13	19.13	65.66	85.33	88.66	64.70				
	30	41.87	88.11	96.70	100.00	81.67	36.66	78.45	93.13	98.00	76.56	33.67	75.91	90.76	95.75	74.02				
	Mean	27.38	66.71	79.6	93.15	66.71	24.27	62.48	76.97	90.86	63.65	21.94	59.73	75.14	88.95	61.44				
	LSD at 0.05	Treatment (a) = 1.14					Concentration (b) = 1.14					days (c) = 1.22					Interaction (a × b × c) = 1.48			
Nymph	10	13.67	39.13	50.13	83.93	46.72	11.66	36.94	47.04	81.66	44.33	10.04	35.00	45.16	79.02	42.31				
	20	17.92	67.66	86.00	91.00	65.65	18.75	65.66	83.02	87.95	63.85	15.00	64.02	82.33	84.66	61.50				
	30	36.66	81.75	91.66	95.13	76.30	31.67	71.60	89.16	93.66	71.52	28.95	71.66	86.00	91.04	69.41				
	Mean	22.75	62.85	75.93	90.02	62.89	20.69	58.07	73.07	87.76	59.90	18.00	56.89	71.16	84.91	57.74				
	LSD at 0.05	Treatment (a) = 1.15					Concentration (b) = 1.15					days (c) = 1.32					Interaction (a × b × c) = 1.52			
Adult	10	15.57	40.67	51.34	84.93	48.13	13.04	38.00	49.66	82.66	45.84	11.92	36.15	48.70	80.43	44.30				
	20	21.67	69.04	87.54	92.66	67.73	20.67	67.68	84.78	88.13	65.32	17.45	64.82	84.42	86.67	63.34				
	30	39.75	86.66	95.15	97.00	79.64	34.75	74.67	90.13	95.67	73.81	31.13	73.04	89.16	94.45	71.95				
	Mean	25.66	65.46	78.01	91.53	65.17	22.82	60.12	74.86	88.82	61.66	20.17	58.00	74.09	87.18	59.86				
	LSD at 0.05	Treatment (a) = 1.13					Concentration (b) = 1.13					days (c) = 1.20					Interaction (a × b × c) = 1.41			

For nymphs, the rates rose from 22.75%, 20.69%, and 18.00% to 90.02%, 87.76%, and 84.91%. In adults, mortality increased from 25.66%, 22.82%, and 20.17% to 91.53%, 88.82%, and 87.18% for oleander, eucalyptus, and mint, respectively.

Among the life stages, larvae showed the highest sensitivity to the extracts after seven days, with mortality rates of 66.71% (oleander), 63.65% (eucalyptus), and 61.44% (mint). Eggs were the least affected, with mortality rates of 58.17%, 55.73%, and

53.95%, respectively.

Bioevaluation of aqueous extracts of oleander, eucalyptus, and mint against broad mite stages under laboratory conditions

This study evaluated the efficacy of aqueous extracts of oleander, eucalyptus, and mint at concentrations of 10, 20, and 30 mg/ml against various developmental stages of the broad mite under laboratory conditions. All extracts significantly reduced mite populations, with oleander being the most effective, followed by

eucalyptus and mint. Mortality rates increased with higher concentrations across all stages (Table 2).

After seven days, egg mortality reached 63.03% (oleander), 61.00% (eucalyptus), and 59.49% (mint). Larval mortality was highest with oleander (78.82%), slightly lower with eucalyptus, and lowest with mint. Nymph mortality followed a similar trend: 74.00% (oleander), 71.08% (eucalyptus), and 68.02% (mint). Adult mortality was 76.38%, 73.19%, and 70.77%, respectively.

Table 2. Bioevaluation of the effectiveness of aqueous extracts from oleander, eucalyptus, and peppermint leaves on the percentage mortality of broad mite, *P. latus* at different developmental stages under laboratory conditions.

Treatment	Concentration	Corrected percentage mortality of <i>P. latus</i> at different days after treatment with alcoholic extracts of leaves of																			
		Oleander					Eucalyptus					Mint									
		1	3	5	7	Mean	1	3	5	7	Mean	1	3	5	7	Mean					
Egg	10	8.58	34.63	43.65	79.52	41.60	7.45	33.75	43.38	78.08	40.67	7.04	31.81	41.02	76.02	38.97					
	20	12.60	61.92	80.92	86.75	60.55	10.81	59.92	78.57	84.78	58.52	9.98	57.23	76.23	82.64	56.52					
	30	14.82	64.10	84.68	88.52	63.03	12.66	61.56	83.75	86.03	61.00	11.89	60.02	81.62	84.42	59.49					
	Mean	12.00	53.55	69.75	84.93	55.06	10.31	51.74	68.57	82.96	53.40	9.64	49.69	66.29	81.03	51.66					
	LSD at 0.05	Treatment (a) = 0.16					concentration (b) = 0. Days (c) = 0.39					Interaction (a × b × c)									
Larvae	10	14.56	39.36	50.21	84.08	47.05	12.52	37.25	48.00	81.04	44.70	11.00	35.08	45.12	79.02	42.56					
	20	20.87	68.04	87.35	90.66	66.73	18.23	65.82	85.04	88.23	64.33	16.23	63.42	82.00	86.03	61.92					
	30	38.89	85.67	93.72	97.00	78.82	33.45	76.98	90.41	94.62	73.87	30.98	74.87	87.30	91.92	71.27					
	Mean	24.77	64.36	77.09	90.58	64.20	21.40	60.02	74.48	87.96	60.97	19.40	57.79	71.47	85.66	58.58					
	LSD at 0.05	Treatment (a) = conc (b) = 1.11					days (c) = 1.18					Interaction (a × b × c) = 1.44									
Nymph	10	11.87	35.64		79.20	43.18	9.89	33.22		76.00	40.59	8.15	30.03	40.10	73.50	37.95					
	20	15.67	64.04	82.12	85.22	61.76	13.34	62.00	79.00	83.02	59.34	11.02	59.50	76.89	81.00	57.10					
	30	33.15	80.45	89.50	92.89	74.00	30.17	77.98	85.67	90.50	71.08	27.12	74.08	83.00	87.89	68.02					
	Mean	20.23	60.04	72.54	85.77	59.65	17.80	57.73	69.30	83.17	57.00	15.43	54.54	66.66	80.80	54.36					
	LSD at 0.05	Treatment (a) = 1.12					concentration (b) = 1.12					days (c) = 1.29					Interaction (a × b × c)				
Adult	10	13.02	37.20	48.04	82.00	45.07	11.14	35.12	45.67	79.04	42.74	9.12	33.04	42.57	77.02	40.44					
	20	18.45	66.00	85.24	88.12	64.45	16.23	63.45	82.98	85.04	61.93	14.00	61.23	79.67	83.00	59.48					
	30	36.64	83.34	91.51	94.04	76.38	31.23	80.34	89.20	92.00	73.19	29.02	77.24	86.98	89.85	70.77					
	Mean	22.7	62.18	74.93	88.05	61.97	19.53	59.64	72.62	85.36	59.29	17.38	57.17	69.74	83.29	56.9					
	LSD at 0.05	Treatment (a) = 1.9					concentration (b) = 1.9					days (c) = 1.16					Interaction (a × b × c) = 1.38				

Mortality rates increased progressively over time. By day seven, egg mortality rose to 84.93% (oleander), 82.96% (eucalyptus), and 81.03% (mint), compared to 12.00%, 10.31%, and 9.64% on day one. Larval mortality increased from 24.77%, 21.40%, and 19.40% on day one to 90.58%, 87.96%, and 85.66% on day seven. Similar trends were observed in nymphs and adults.

The effectiveness of the extracts is attributed to toxic bioactive compounds that act through

ingestion and contact, disrupting neural, enzymatic, and metabolic processes (Mukhtar et al., 2013). Oleander's potency is linked to cardiac glycosides such as oleandrin and digitoxin, which impair feeding and induce paralysis. GC-MS analysis by Hameed et al. (2015) identified compounds like 5-hydroxymethylfurfural and alkaloids in *Nerium oleander* contributing to its acaricidal activity. Eucalyptus contains terpenoids and hexane derivatives (Yassen, 2014), while mint's insecticidal activity is due to

volatile oils such as menthol and limonene (Raja et al., 2003; Hawrył et al., 2015).

The findings obtained from the leaf disc experiment (Deka et al., 2022) showed that all selected plant extracts from five traditional plants, *Murraya paniculata*, *Cassia tora*, *Amphineuron opulentum*, *Tithonia diversifolia*, and *Cassia alata*, exhibited acaricidal activity, with 52-82% mortality of adult red spider mites (*Oligonychus coffeae*) recorded at the highest dose (10 g/L) after 72 h.

Estimation of population density of *P. latus* at different developmental stages on two roselle cultivars

The population dynamics of *P. latus* at various developmental stages were monitored in a lath house from September 15, 2022, to April 12, 2023, on two roselle cultivars, yellow and dark red. Infestation began shortly after transplanting in mid-September. As shown in Table 3, a significant difference in egg density was observed between cultivars, with the yellow cultivar showing an initial average of 3.90 eggs per leaf compared to 2.16 in the dark red, under 37.93°C maximum temperature, 21.45°C minimum, and 25.56% relative humidity (Figure 1).

Table 3. Population density of *P. latus* eggs on two roselle cultivars.

Date	Average number of eggs per leaf		
	Yellow cultivar	Dark red cultivar	T-test
15/09/2022	3.90	2.16	1.443*
25/09/2022	5.90	4.83	1.444NS
05/10/2022	8.93	6.93	0.068*
15/10/2022	10.90	9.26	2.162NS
25/10/2022	11.93	10.86	1.603NS
04/11/2022	14.00	11.93	3.590NS
14/11/2022	16.83	14.73	3.238NS
24/11/2022	19.23	16.86	1.573*
04/12/2022	16.83	14.93	1.637*
14/12/2022	15.26	13.73	2.267NS
24/12/2022	12.73	11.70	1.627NS
03/01/2023	9.80	8.63	2.267NS
13/01/2023	7.03	4.60	0.069*
23/01/2023	4.90	2.93	3.21NS
02/02/2023	2.10	1.63	0.161*
12/02/2023	1.50	0.97	0.278*
22/02/2023	2.56	1.10	1.611NS
03/03/2023	3.20	2.93	3.638NS
13/03/2023	4.33	3.96	1.619NS
23/03/2023	5.76	5.03	1.579NS
02/04/2023	7.16	6.9	2.272NS
12/04/2023	11.26	9.00	2.267NS
Mean	8.91	7.53	1.285 *

* = Significant at $P \leq 0.05$; NS = Non-significant at $P \geq 0.05$.

Egg populations increased gradually after initial infestation, with no significant difference between cultivars until the third ten-day period of November, when densities peaked at 19.23 (yellow) and 16.86 (dark red) eggs per leaf. This peak coincided with 27.44°C

maximum, 13.02°C minimum, and 46.09% humidity. Egg densities then declined, reaching their lowest in December and early February: 1.50 eggs per leaf (yellow) and 0.97 (dark red), under 17.72°C maximum, 4.06°C minimum, and 48.72% humidity. A second peak occurred in April, with 11.26 (yellow) and 9.00 (dark red) eggs per leaf at 25.16°C maximum, 13.59°C minimum, and 58.37% humidity. These results indicated two annual peaks, autumn and spring, with a more prominent peak in autumn due to more favorable conditions.

Larval densities showed no significant differences between cultivars until early February, starting at ~1.8-2.0 larvae per leaf. The population peaked in late November at 16.23 (yellow) and 14.30 (dark red) larvae per leaf. Numbers declined from December, reaching their lowest in February (1.23 and 0.96 larvae per leaf), then rose again in April with a second peak (10.76 and 8.63 larvae per leaf) as shown in Table 4.

Table 4. Population density of *P. latus* larvae on two Roselle varieties.

Date	Average number of eggs per leaf		
	Yellow cultivar	Dark red cultivar	T-test
15/09/2022	2.00	1.70	1.626NS
25/09/2022	4.63	3.70	2.227NS
05/10/2022	8.66	6.60	3.249NS
15/10/2022	10.63	8.80	2.272NS
25/10/2022	11.63	10.4	2.790NS
04/11/2022	13.6	11.46	2.377NS
14/11/2022	14.56	12.7	3.222NS
24/11/2022	16.23	14.3	3.998NS
04/12/2022	14.93	13.16	2.261NS
14/12/2022	12.00	10.93	3.926NS
24/12/2022	8.23	8.00	3.206NS
03/01/2023	5.26	3.96	3.194NS
13/01/2023	4.53	2.93	3.936NS
23/01/2023	2.68	1.89	1.956NS
02/02/2023	1.80	1.30	0.506NS
12/02/2023	1.23	0.96	0.045*
22/02/2023	2.86	1.58	1.611NS
03/03/2023	4.03	2.16	3.182NS
13/03/2023	6.56	5.46	5.059NS
23/03/2023	8.33	7.36	2.256NS
02/04/2023	9.30	8.53	3.358NS
12/04/2023	10.76	8.63	2.255NS
Mean	7.93	6.66	2.612NS

* = Significant at $P \leq 0.05$; NS = Non-significant at $P \geq 0.05$.

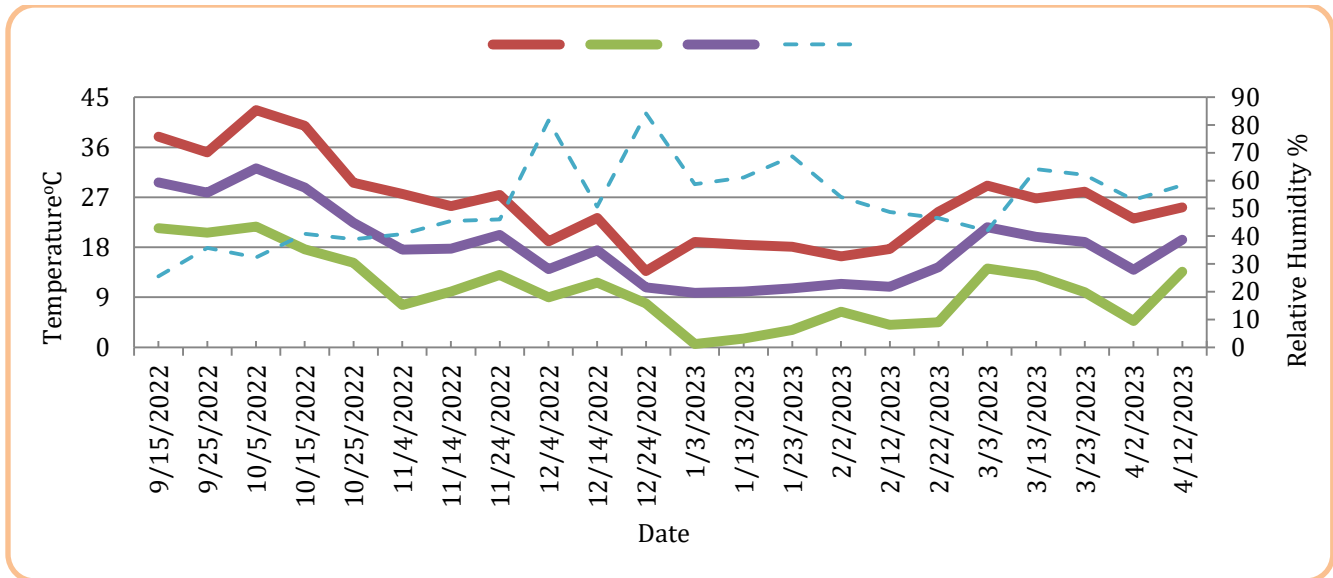


Figure 1. Daily averages of maximum and minimum temperatures and relative humidity in the Al-Jadriyah area, Baghdad, from September 15, 2022, to April 12, 2023.

Nymph and adult populations followed similar trends (Table 5 and 6). The highest peak occurred in late November, with 18.10 and 16.96 nymphs, and 16.53 and 14.60 adults per leaf (yellow and dark red, respectively). The second peak in early April recorded 11.06 nymphs and 11.80 adults (yellow), and 9.23 nymphs and 10.40 adults (dark red) (Table 5 and 6). Population fluctuations were closely associated with environmental conditions, optimal temperature and humidity favored mite development and reproduction.

Statistical analysis revealed significantly higher population densities in the yellow cultivar across all stages: eggs (8.91 vs. 7.53), larvae (7.93 vs. 6.66), nymphs (7.78 vs. 6.53), and adults (7.63 vs. 6.17), suggesting greater susceptibility. The higher mite load on the yellow cultivar may be linked to its higher nitrogen content, which enhances amino acid synthesis and supports mite growth. In contrast, the dark red cultivar may possess natural defense compounds that inhibit feeding, offering partial resistance. Temperature, humidity, and plant maturity were key factors influencing *P. latus* development, with extreme weather conditions limiting population growth and optimal conditions supporting year-round activity.

Evaluation of the efficacy of alcoholic and aqueous extracts of oleander, eucalyptus, and mint in controlling *P. latus* under field conditions

Laboratory bioassays showed that the 30 mg/ml

concentration of both alcoholic and aqueous extracts of oleander, eucalyptus, and mint was the most effective and was selected for field trials. This concentration significantly reduced pest populations while minimizing environmental impact and control costs.

Field results revealed that efficacy varied over time. Oleander alcohol extract showed the highest effectiveness against adults of *P. latus*, with a relative effectiveness of 79.11%, followed by eucalyptus (75.93%) and mint (72.83%) alcohol extracts. Aqueous extracts of oleander and eucalyptus showed 68.72% and 63.77% effectiveness, respectively, while mint aqueous extract was least effective at 60.37%.

All treatments had rapid effects within one day, with oleander alcohol extract being the most potent. Initial effectiveness ranged from 37.66% to 65.00%, increasing to peak levels at day 14: 96.67% (oleander alcohol), 94.00% (eucalyptus alcohol), and 92.51% (mint alcohol). However, efficacy declined by day 21 to 33-55%, likely due to the extracts' contact and stomach poison modes of action, which disrupt neural and enzymatic functions.

Oleander alcohol extract also showed the highest efficacy against immature stages, reaching 81.73% against larvae and nymphs. Alcohol extracts consistently outperformed aqueous ones, likely due to better solubility of bioactive compounds in ethanol (dielectric constant 24.5) compared to water (78.4) (Bernard, 1997; Al-Myah et al., 2011).

Table 5. Population density of *P. latus* nymphs on two roselle cultivars.

Date	Average number of eggs per leaf		
	Yellow cultivar	Dark red cultivar	T-test
15/09/2022	2.43	1.50	1.595 NS
25/09/2022	3.98	2.30	2.334 NS
05/10/2022	7.43	5.56	2.272 NS
15/10/2022	10.3	7.43	2.289 *
25/10/2022	11.26	9.23	3.214 NS
04/11/2022	14.76	12.16	3.210 NS
14/11/2022	16.16	14.06	2.267 NS
24/11/2022	18.10	16.96	4.519 NS
04/12/2022	15.90	13.03	2.278 *
14/12/2022	11.53	10.63	2.790 NS
24/12/2022	7.93	7.66	3.234 NS
03/01/2023	4.93	3.56	1.611 NS
13/01/2023	2.06	1.86	1.611 NS
23/01/2023	1.40	1.16	0.165 *
02/02/2023	1.16	0.86	0.027 *
12/02/2023	0.70	0.43	0.280 NS
22/02/2023	1.93	1.43	0.660 *
03/03/2023	3.70	2.16	3.206 NS
13/03/2023	4.86	3.16	1.619 *
23/03/2023	8.70	7.10	4.593 NS
02/04/2023	10.83	8.30	2.442 *
12/04/2023	11.06	9.23	2.289 NS
Mean	7.78	6.35	1.605 NS

* = Significant at $P \leq 0.05$; NS = Non-significant at $P \geq 0.05$.

Supporting studies, such as Nahal and Afram (2020), found eucalyptus extract effective against immature stages of the potato tuber moth, highlighting its potential in pest management. These plant-based extracts degrade rapidly under environmental conditions, posing fewer risks to human health than synthetic pesticides, which can persist in soil and on crops (Isman, 2000; Caboni et al., 2006). Prior research confirmed the bioactivity of pesticidal plants against a range of pests and pathogens (Sarmah et al., 1999; Raja et al., 2003; Hussain et al., 2011; Roy et al., 2012; Deka et al., 2017; Khan et al., 2021), though further studies are needed on their impacts on field crop performance and tri-trophic interactions.

CONCLUSION

The present study demonstrated the effectiveness of plant-based extracts, including alcoholic and aqueous extracts of oleander, eucalyptus, and mint, in controlling

the broad mite (*Polyphagotarsonemus latus*). The results revealed significant differences in mortality rates across developmental stages, with alcoholic extracts showing greater efficacy than aqueous extracts. These findings suggest that herbal extracts, particularly when applied at optimal concentrations, can serve as sustainable and eco-friendly alternatives to conventional synthetic pesticides. Integrating these natural extracts into pest management strategies could help reduce dependence on chemical pesticides, preserve beneficial natural enemies, and promote sustainable agricultural practices. However, further research is needed to optimize application methods, evaluate compatibility with natural predators, and determine the long-term effectiveness of these extracts under both protected and open-field conditions.

Table 6. Population density of *P. latus* adults on two roselle cultivars.

Date	Average number of eggs per leaf		
	Yellow cultivar	Dark red cultivar	T-test
15/09/2022	2.76	1.61	1.595 NS
25/09/2022	4.56	2.80	3.229 NS
05/10/2022	8.80	6.80	3.370 NS
15/10/2022	10.66	9.00	2.776 NS
25/10/2022	11.76	10.56	2.261 NS
04/11/2022	13.76	11.76	3.226 NS
14/11/2022	14.73	12.86	2.261 NS
24/11/2022	16.53	14.60	5.069 NS
04/12/2022	13.46	11.43	4.253 NS
14/12/2022	11.13	9.20	2.278 NS
24/12/2022	8.13	6.73	2.284 NS
03/01/2023	4.16	3.03	2.267 NS
13/01/2023	2.10	1.80	0.226 *
23/01/2023	1.60	1.10	0.160 NS
02/02/2023	0.88	0.56	0.032 *
12/02/2023	0.51	0.36	0.042 *
22/02/2023	1.90	1.43	0.016 *
03/03/2023	4.13	2.96	2.255 NS
13/03/2023	6.76	4.50	1.643 *
23/03/2023	8.43	6.73	2.295 NS
02/04/2023	9.36	8.50	1.763 NS
12/04/2023	11.80	10.40	2.162 NS
Mean	7.63	6.17	1.752 NS

* = Significant at $P \leq 0.05$; NS = Non-significant at $P \geq 0.05$.

Table 7. Relative effectiveness of alcoholic and aqueous extracts of oleander, eucalyptus and mint against broad mite, *P. latus* in two roselle cultivars under field.

Stage	Type of extract	Corrected percentage mortality (days after treatment)						
		1	3	5	7	14	21	Mean
Adult	Alcoholic oleander extract 30 mg/ml	65.00	78.33	87.33	93.00	96.67	54.33	79.11
	Alcoholic eucalyptus extract 30 mg/ml	62.67	75.00	83.04	91.02	94.00	49.82	75.93
	Alcoholic mint extract 30 mg/ml	59.33	70.55	79.89	88.67	92.51	46.05	72.83
	Aqueous oleander extract 30 mg/ml	45.00	67.00	78.33	85.67	91.00	45.33	68.72
	Aqueous eucalyptus extract 30 mg/ml	40.13	62.67	71.61	81.59	87.92	38.67	63.77
	Aqueous mint extract 30 mg/ml	37.66	56.52	69.12	79.82	85.67	33.45	60.37
	Average for days	51.63	68.35	78.22	86.63	91.3	44.61	70.12
	LSD0.05	Extract (a) = 0.62, Days (b) = 1.04, Interaction (a × b) = 1.89						
Nymph	Alcoholic oleander extract 30 mg/ml	63.00	77.57	82.00	90.23	95.02	50.42	76.37
	Alcoholic eucalyptus extract 30 mg/ml	60.41	70.33	79.67	88.14	93.06	47.33	73.16
	Alcoholic mint extract 30 mg/ml	56.33	66.12	74.15	84.55	90.33	44.67	69.36
	Aqueous oleander extract 30 mg/ml	36.00	60.67	71.89	82.33	88.00	34.33	62.20
	Aqueous eucalyptus extract 30 mg/ml	34.04	57.33	68.14	78.05	86.62	30.67	59.14
	Aqueous mint extract 30 mg/ml	30.55	52.18	65.67	75.33	83.66	28.67	56.01
	Average for days	46.72	64.03	73.59	83.11	89.45	39.35	66.04
	LSD0.05	Extract (a) = 0.77, Days (b) = 1.10, Interaction (a × b) = 2.19						
Larva	Alcoholic oleander extract 30 mg/ml	69.92	80.04	89.30	95.04	98.89	57.16	81.73
	Alcoholic eucalyptus extract 30 mg/ml	65.12	76.82	86.67	92.04	95.45	54.33	78.41
	Alcoholic mint extract 30 mg/ml	61.06	72.24	83.33	90.55	93.00	51.66	75.31
	Aqueous oleander extract 30 mg/ml	.0049	69.00	80.18	88.67	90.00	48.67	70.92
	Aqueous eucalyptus extract 30 mg/ml	45.63	64.12	77.07	84.00	88.22	42.50	66.92
	Aqueous mint extract 30 mg/ml	41.67	60.55	72.63	80.45	86.04	38.89	63.37
	Average for days	55.40	70.46	81.53	88.46	91.93	48.87	72.78
	LSD0.05	Extract (a) = 1.05, Days (b) = 1.12, Interaction (a × b) = 2.04						
Eggs	Alcoholic oleander extract 30 mg/ml	37.00	75.65	80.32	89.67	94.00	41.64	69.71
	Alcoholic eucalyptus extract 30 mg/ml	33.67	71.33	78.00	85.67	92.33	38.55	66.59
	Alcoholic mint extract 30 mg/ml	31.00	70.00	77.67	83.05	91.67	36.33	64.95
	Aqueous oleander extract 30 mg/ml	24.67	54.33	75.67	81.00	89.40	34.75	59.97
	Aqueous eucalyptus extract 30 mg/ml	21.12	50.44	71.05	76.67	86.89	32.02	56.37
	Aqueous mint extract 30 mg/ml	19.04	48.33	69.67	74.00	84.55	30.24	54.31
	Average for days	27.75	61.68	75.40	81.68	89.81	35.59	61.98
	LSD 0.05	Extract (a) = 60.6, Days (b) = 1.19, Interaction (a × b) = 2.66						

RECOMMENDATION

Further research is recommended to investigate the feeding preferences of broad mites on various *Hibiscus* species, other Malvaceae plants, and alternative host species, with a focus on the relationship between plant morphological, biochemical, and nutritional traits and their influence on broad mites, other associated pests, and natural enemies. In addition, ecological and

biological studies should be conducted on predatory and parasitic mites and insects that affect *P. truncatula*, with the goal of enhancing their role in pest suppression and incorporating them into integrated pest management (IPM) programs for both protected and open-field cultivation. To support sustainable agriculture, farmers should be trained on the importance of avoiding pesticides that harm beneficial organisms, thereby

ensuring the conservation of natural enemies. Moreover, additional studies on the alcoholic and aqueous extracts of oleander, eucalyptus, and mint are essential to evaluate their potential for integration into IPM strategies targeting broad mites.

AUTHORS' CONTRIBUTIONS

HKJA, SAKA, and LBY prepared the materials, collected the data, and performed statistical analysis using the GenStat program; HKJA identified the broad mite, *Polyphagotarsonemus latus*, using the taxonomic key based on the reference by Krantz and Walter (2009); All authors contributed to writing and revising the manuscript.

RESEARCH FUNDING

This research did not receive any grant from funding agencies.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

SUSTAINABLE DEVELOPMENT GOALS TARGETED

SDG 2: Zero Hunger

SDG 12: Responsible Consumption and Production

SDG 15: Life on Land

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