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The First Study for The Acaricidal Activity of Alcoholic Extracts of *Adiantum capillus-veneris* and *Funaria hygrometric* against *Argas persicus*

Mai Ahmed Taha[1]* and Asmaa Ali Baioumy Ali[2]
1-Botany Department, Faculty of Science, Ain Shams University, Cairo, Egypt.
2-Zoology Department, Faculty of Science, Ain Shams University, Cairo, Egypt.
E-mail : maitaha33@yahoo.com - Asmaaali86@sci.asu.edu.eg

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ABSTRACT

The present study was conducted to investigate the acaricidal activity of ethanolic and methanolic extracts of two Cryptogams plants, namely *Adiantum capillus-veneris* (fern plant) and *Funaria hygrometrica* (moss plant) at different concentrations (1%, 2%, 3%, and 4%) on semi-fed females of *Argas persicus* (away from their hosts) collected from the field. The percentages of mobile, immobile, and dead females were recorded two-day intervals for 30 days after treatment with all extracts assayed at different concentrations, using the dipping method. The results indicated that all extracts at different concentrations caused a significant decrease in the percentages of mobile ticks and a significant increase in the percentages of dead ones when compared with the control. The acaricidal efficacy of *A. capillus-veneris* and *F. hygrometrica* extracts may be attributed to their contents of many active phytochemical constituents that having high potential against ticks. At the highest concentration (4%), the percentage of tick mortality for methanolic extract was more efficient than ethanolic one for both plants recording 100% efficiency for *A. capillus-veneris* and 50% for *F. hygrometrica*. So, we recommended using *A. capillus-veneris* methanolic extract at 4% as a herbal pesticide against *A. persicus* which have all characters of ideal pesticides; effective (100% acaricidal activity), easily available, cheap, biodegradable (eco-friendly), and do not cause mammalian toxicity.

INTRODUCTION

Ticks are belonging to the phylum Arthropoda, class Arachnida. They are obligate blood-sucking ectoparasites of a broad range of vertebrates and sometimes attack humans (Yu *et al.*, 2015). Symptoms of their attack vary from minor itching, irritation, anemia, and weight loss to extreme annoyance and fatigue, malnutrition, and even death (Nasibeh *et al.*, 2010; Jafarbekloo *et al.*, 2014). Moreover, tick saliva causes severe toxic conditions such as paralysis which may be fatal (Hoogstraal, 1985; Mans *et al.*, 2008).

Argas persicus (Argasidae; soft ticks) is the most important ectoparasite of chicken and other domestic fowl, as well as humans (Tavassoli *et al.*, 2015). Moreover, it acts as a vector for some bacteria and viruses to poultry (Barker and Walker, 2014; Bhat *et al.*,

2014), and several pathogens to the human e.g. virus of Kyasanur forest disease (Singh *et al.*, 1971; Veraldi *et al.*, 1998; Uspensky, 2008).

Tick control has remained an area of researchers' interest (Sahito *et al.*, 2013). The acaricides are quite expensive and have adverse environmental impacts besides the resistance that ticks have developed (Sahito *et al.*, 2013; Lonc *et al.*, 2014); therefore, the search for alternatives was essential.

It is not strange using plant extracts as pesticides, especially for the management of ticks; a lot of botanists dealing with this goal (Ghosh *et al.*, 2015a; Adenubi *et al.*, 2016; Islam *et al.*, 2018; Kemal *et al.*, 2020; Mahran *et al.*, 2020), but it is rare to use Cryptogams (i.e. bryophytes and pteridophytes) in this regard. Cryptogams were used as pesticides (Oehme *et al.*, 1985; Adebiyi and Tedela, 2012; Srivastava, 2015; Rashid, 2016; Glime, 2017), but their use to manage ticks is a novel in-vitro study; despite in-vivo farmers indicated their efficiency as a pesticide against ticks without laboratory experiments (Williams, 2012).

The current aim of this study is to obtain a novel cheap, eco-friendly, abundant (grow in numerous habitats and different regions), easy-to-obtain, and high-efficiency anti-ticks by using two different species of Cryptogams (*Adiantum capillus-veneris* L. and *Funaria hygrometrica* Hedw.) alcoholic extracts for the first time in the world including Egypt.

MATERIALS AND METHODS

Study Area, Collection, and Identification of the Plant Materials:

Plant materials were collected from 6 October, Ein Shams region, Cairo, Egypt, at 31° 21′ 10″ E and 30° 8′ 8″ N, 16m above sea level; which were found growing on highly wet, shaded cement walls.

Two Cryptogams plants were gathered on 17 February 2019 and all materials have been housed in CAIA for further investigations. The two plants were identified according to their morphological and/or anatomical characters as *Adiantum capillus-veneris* L. (Pteridophyta, Polypodiales, Pteridaceae) and *Funaria hygrometrica* Hedw. (Bryophyta, Funariales, Funariaceae).

Plant Preparation and Extraction:

Rhizoids and/or roots have been removed then the plants (sporophyte of *A. capillus-veneris* and gametophyte carrying sporophyte of *F. hygrometrica*) were treated with 0.8% Tween 80 solution (to remove epiphytic hosts) and washing many times with tap water, also cleaned gently by using needles to remove any sticking soil particles then washed by distilled water as a final cleaning step.

The method of plant extractions is modified from Adebiyi and Tedela (2012). The clean plants were dried on filter papers away from direct sunlight. After complete drying, they were ground into powder by using a blender. The powdered plants portioned and suspended for 24hrs in ethanol (95%) or methanol (99.9%) solutions to obtain 1%, 2%, 3%, and 4% of plant extracts. The extracts were centrifuged at 300 rpm for 15 min. and the supernatants were maintained at -4 ˚C until the time of the experiments.

Tick Origin and Colonization:

Argas persicus used in the present study was collected from a fowl house in Abo Rawash area, Kerdasa District, Giza Governorate, Egypt at 31° 4′18″ E and 30° 1′ 33″ N and maintained in the Faculty of Science laboratories, Ain Shams University, Cairo, Egypt. Ticks were identified according to Balashov (1972), and semi-fed females were separated, then reared in glass vials covered by a piece of gauze. The rearing vials were placed in an incubator adjusted at 28±1 ˚C and 75±5% of relative humidity until the experiment's time.

Plant Extract Treatment:

Ticks were treated by using the dipping method. Each concentration of both plant extracts was applied separately to semi-fed females from the field away from their host.

Three replicates were made for each concentration in both plant extracts. Each trial included ten females, which were placed in a 9 cm Petri dish and were dipped with five ml of each concentration for 5 min. Then, ticks have been transferred to sterilize filter paper to absorb the excess of extract and transferred to glass vials containing small pieces of filter paper and put into the incubator adjusted at 28±1 ˚C and 75±5% of relative humidity.

The dipped ticks with plant extracts in each experiment are referred to hereinafter as treated and compared with untreated ones: control (dipped in 95% ethanol, 99.9% methanol, or distilled water). Untreated and treated ticks were then observed during the 30 days following treatment for their mobility and viability.

Mobility was determined by the percentages of mobile and immobile ticks during the 30 days following treatment (Ali, 2013, 2018). Specimens were pressed several times to check their movement. Viability was determined by the percentages of live and dead ones. Ticks were regarded as dead when their legs did not move after they were forcibly stretched.

RESULTS

The current results included studying the efficacy of ethanolic and methanolic extracts of *Adiantum capillus-veneris* and *Funaria hygrometrica* at different concentrations; 1%, 2%, 3%, and 4% (separately) against semi-fed females of *Argas persicus* (away from their hosts), 2-day interval along 30 days using the dipping method. It's worth noted that there was no effect on ticks (100% mobility) in the control groups either dipped in ethanol, methanol, or distilled water throughout the examined period (Tables 1 and 2; Figs. 1-4).

Effect of Ethanolic and Methanolic Extracts of *Adiantum capillus-veneris* on the Mobility and Viability of Semi-Fed Female *Argas persicus* from the Field:

During the examination of the effect of *A. capillus-veneris* ethanolic extract at 1%, 2%, 3%, and 4% on the percentages of mobile females; it was noticed that the percentages decreased as 70%, 33.3%, 33.3%, and 20%, respectively throughout the examination period (Table 1; Fig. 1). On the other hand, the percentages of immobile females, which were treated with the same concentrations, were recorded 16.7%, 16.7%, 3.3%, and 10% respectively 30thday after treatment. Also, the percentages of dead females increased to 13.3%, 50%, 63.4%, and 70%, respectively at the end of the 30th day (Table 1; Fig. 1).

The percentages of mobile females were decreased along the examined period being 96.7-86.7%, 90-70%, 80-66.7%, and 0% when treated with methanolic extract of *A. capillus-veneris* at concentrations of 1%, 2%, 3%, and 4%, respectively (Table 1; Fig. 2). On the other hand, the percentages of immobile ticks were changing unevenly to be 13.3%, 10%, 13.3%, and 0% in those treated with the same above concentrations, respectively 30th day after treatment. Meanwhile, the percentage of dead females recorded 0%, 20%, 20%, and 100% by treating with the above concentrations, respectively at the end of the examination period (Table 1; Fig. 2).

Table 1. Effect of ethanolic and methanolic extracts of *Adiantum capillus-veneris* at different concentrations on the mobility and viability of semi-fed female *Argas persicus*.

		Control	Ethanol Extract				Methanol Extract			
			1%	2%	3%	4%	1%	2%	3%	4%
2 days	M	100	70	33.3	33.3	20	96.7	90	80	0
	I	0	30	66.7	66.7	70	3.3	3.3	20	90
	D	0	0	0	0	10	0	6.7	0	10
4 days	M	100	70	33.3	33.3	20	96.7	83.3	80	0
	I	0	30	66.7	66.7	70	3.3	10	16.7	90
	D	0	0	0	0	10	0	6.7	3.3	10
6 days	M	100	70	33.3	33.3	20	96.7	80	76.7	0
	I	0	30	66.7	63.3	70	3.3	13.3	20	90
	D	0	0	0	3.3	10	0	6.7	3.3	10
8 days	M	100	70	33.3	33.3	20	96.7	80	76.7	0
	I	0	30	66.7	56.7	70	3.3	13.3	13.3	90
	D	0	0	0	10	10	0	6.7	10	10
10 days	M	100	70	33.3	33.3	20	96.7	80	76.7	0
	I	0	23.3	66.7	56.7	70	3.3	13.3	13.3	90
	D	0	6.7	0	10	10	0	6.7	10	10
12 days	M	100	70	33.3	33.3	20	96.7	80	76.7	0
	I	0	20	56.7	46.7	70	3.3	10	13.3	50
	D	0	10	10	20	10	0	10	10	50
14 days	M	100	70	33.3	33.3	20	96.7	80	76.7	0
	I	0	16.7	26.7	33.3	70	3.3	10	13.3	50
	D	0	13.3	40	33.4	10	0	10	10	50
16 days	M	100	70	33.3	33.3	20	96.7	80	76.7	0
	I	0	16.7	26.7	33.3	50	3.3	0	13.3	50
	D	0	13.3	40	33.4	30	0	20	10	50
18 days	M	100	70	33.3	33.3	20	96.7	80	76.7	0
	I	0	16.7	26.7	20	50	3.3	0	13.3	50
	D	0	13.3	40	46.7	30	0	20	10	50
20 days	M	100	70	33.3	33.3	20	96.7	80	76.7	0
	I	0	16.7	26.7	20	30	3.3	0	13.3	40
	D	0	13.3	40	46.7	50	0	20	10	60
22 days	M	100	70	33.3	33.3	20	96.7	80	76.7	0
	I	0	16.7	16.7	3.3	10	3.3	0	10	0
	D	0	13.3	50	63.4	70	0	20	13.3	100
24 days	M	100	70	33.3	33.3	20	96.7	80	76.7	0
	I	0	16.7	16.7	3.3	10	3.3	0	10	0
	D	0	13.3	50	63.4	70	0	20	13.3	100
26 days	M	100	70	33.3	33.3	20	96.7	80	76.7	0
	I	0	16.7	16.7	3.3	10	3.3	0	10	0
	D	0	13.3	50	63.4	70	0	20	13.3	100
28 days	M	100	70	33.3	33.3	20	96.7	80	76.7	0
	I	0	16.7	16.7	3.3	10	3.3	0	10	0
	D	0	13.3	50	63.4	70	0	20	13.3	100
30 days	M	100	70	33.3	33.3	20	86.7	70	66.7	0
	I	0	16.7	16.7	3.3	10	13.3	10	13.3	0
	D	0	13.3	50	63.4	70	0	20	20	100

M= Mobile, I= Immobile, D= Dead

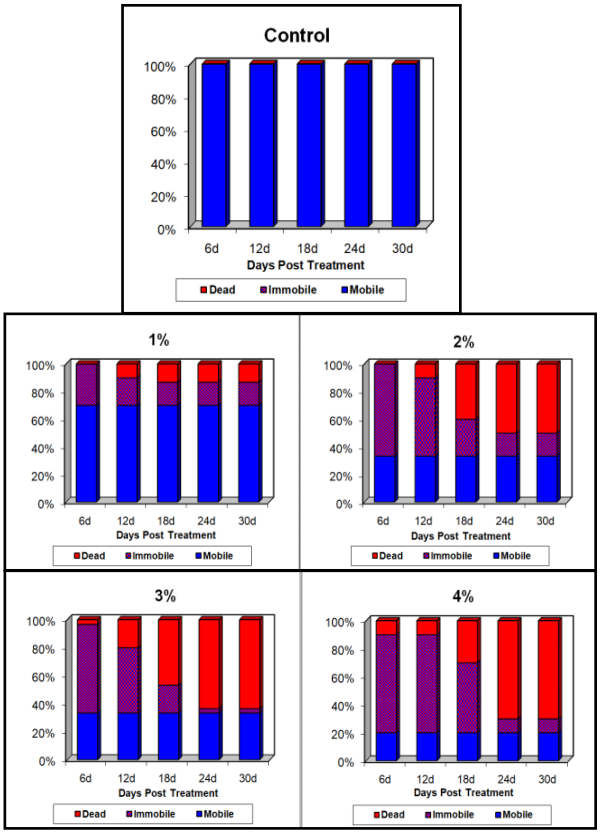

Fig.1. Effect of ethanolic extract of *Adiantum capillus-veneris* at different concentrations on the mobility and viability of semi-fed female *Argas persicus*.

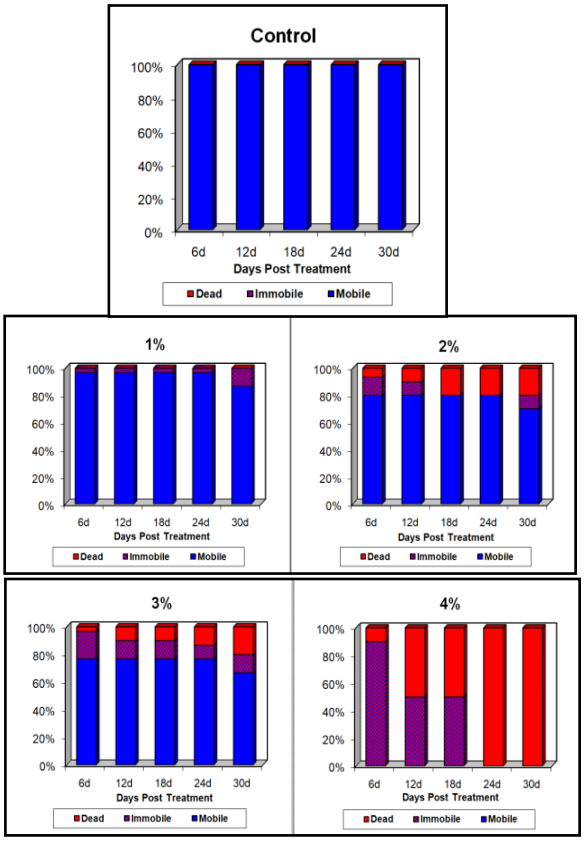

Fig.2. Effect of methanolic extract of *Adiantum capillus-veneris* at different concentrations on the mobility and viability of semi-fed female *Argas persicus*.

Effect of Ethanolic and Methanolic Extracts of *Funaria hygrometrica* on the Mobility and Viability of Semi-Fed Female *Argas persicus* from the Field:

The results showed that the percentages of mobile females of *A. persicus* were markedly decreased after treatment with 1%, 2%, 3%, and 4% ethanolic extract of *F. hygrometrica* to recording 76.7%, 60%, 26.7%, and 20%, respectively at the end of the 30th day (Table 2; Fig. 3). On the other side, the percentages of immobile ones were recorded 3.3%, 23.3%, 33.3%, and 40% by using the above concentrations, respectively after 30 days of treatment. Also, the percentages of dead ones increased to 20%, 16.7%, 40%, and 40% in the serial used concentrations, respectively at the end of the examination period (Table 2; Fig. 3).

The percentages of mobile females, which treated with methanolic extracts of *F. hygrometrica* were decreased directly proportional to the examined period being 96.7-56.7%, 73.3-50%, 63.3-43.3%, and 53.3-40% in those treated with 1%, 2%, 3%, and 4%, respectively (Table 2; Fig. 4). The percentages of immobile females changed to be 3.3-30%, 26.7-50%, 36.7-43.3%, and 46.7-10% by using the above concentrations, respectively throughout the examination period. Whereas, the percentage of dead ones increased directly proportional to the concentrations and the time together to be 0-13.3%, 0%, 0-13.4%, and 0-50% in those treated with 1%, 2%, 3%, and 4%, respectively.

Table 2. Effect of ethanolic and methanolic extracts of *Funaria hygrometrica* at different concentrations on the mobility and viability of semi-fed female *Argas persicus*.

		Control	Ethanol Extract				Methanol Extract			
			1%	2%	3%	4%	1%	2%	3%	4%
2 days	M	100	76.7	60	26.7	20	96.7	73.3	63.3	53.3
	I	0	23.3	40	73.3	80	3.3	26.7	36.7	46.7
	D	0	0	0	0	0	0	0	0	0
4 days	M	100	76.7	60	26.7	20	90	60	63.3	53.3
	I	0	23.3	40	73.3	80	10	40	36.7	46.7
	D	0	0	0	0	0	0	0	0	0
6 days	M	100	76.7	60	26.7	20	90	50	53.3	53.3
	I	0	23.3	33.3	73.3	80	10	50	46.7	46.7
	D	0	0	6.7	0	0	0	0	0	0
8 days	M	100	76.7	60	26.7	20	80	50	53.3	53.3
	I	0	20	33.3	70	60	20	50	46.7	46.7
	D	0	3.3	6.7	3.3	20	0	0	0	0
10 days	M	100	76.7	60	26.7	20	76.7	50	53.3	53.3
	I	0	13.3	23.3	50	60	20	50	46.7	46.7
	D	0	10	16.7	23.3	20	3.3	0	0	0
12 days	M	100	76.7	60	26.7	20	76.7	50	53.3	40
	I	0	13.3	23.3	50	60	20	50	43.3	50
	D	0	10	16.7	23.3	20	3.3	0	3.3	10
14 days	M	100	76.7	60	26.7	20	76.7	50	53.3	40
	I	0	10	23.3	50	60	20	50	36.7	50
	D	0	13.3	16.7	23.3	20	3.3	0	10	10
16 days	M	100	76.7	60	26.7	20	76.7	50	53.3	40
	I	0	10	23.3	43.3	50	20	50	33.3	50
	D	0	13.3	16.7	30	30	3.3	0	13.4	10
18 days	M	100	76.7	60	26.7	20	76.7	50	53.3	40
	I	0	10	23.3	43.3	50	20	50	33.3	50
	D	0	13.3	16.7	30	30	3.3	0	13.4	10
20 days	M	100	76.7	60	26.7	20	76.7	50	53.3	40
	I	0	10	23.3	43.3	50	20	50	33.3	50
	D	0	13.3	16.7	30	30	3.3	0	13.4	10
22 days	M	100	76.7	60	26.7	20	60	50	53.3	40
	I	0	10	23.3	33.3	40	30	50	33.3	20
	D	0	13.3	16.7	40	40	10	0	13.4	40
24 days	M	100	76.7	60	26.7	20	60	50	46.7	40
	I	0	10	23.3	33.3	40	30	50	40	10
	D	0	13.3	16.7	40	40	10	0	13.3	50
26 days	M	100	76.7	60	26.7	20	60	50	46.7	40
	I	0	10	23.3	33.3	40	30	50	40	10
	D	0	13.3	16.7	40	40	10	0	13.3	50
28 days	M	100	76.7	60	26.7	20	60	50	46.7	40
	I	0	10	23.3	33.3	40	30	50	40	10
	D	0	13.3	16.7	40	40	10	0	13.3	50
30 days	M	100	76.7	60	26.7	20	56.7	50	43.3	40
	I	0	3.3	23.3	33.3	40	30	50	43.3	10
	D	0	20	16.7	40	40	13.3	0	13.4	50

M= Mobile, I= Immobile, D= Dead

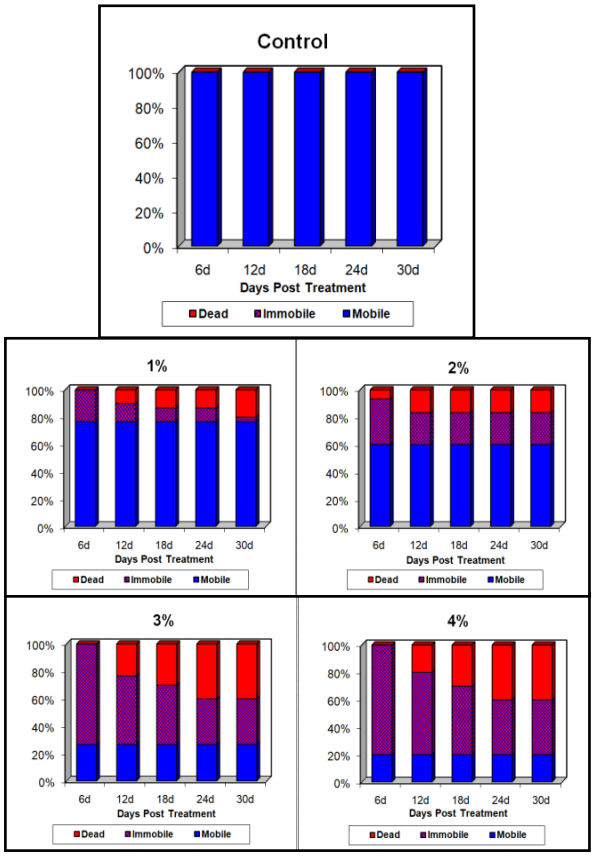

Fig. 3. Effect of ethanolic extract of *Funaria hygrometrica* at different concentrations on the mobility and viability of semi-fed female *Argas persicus*.

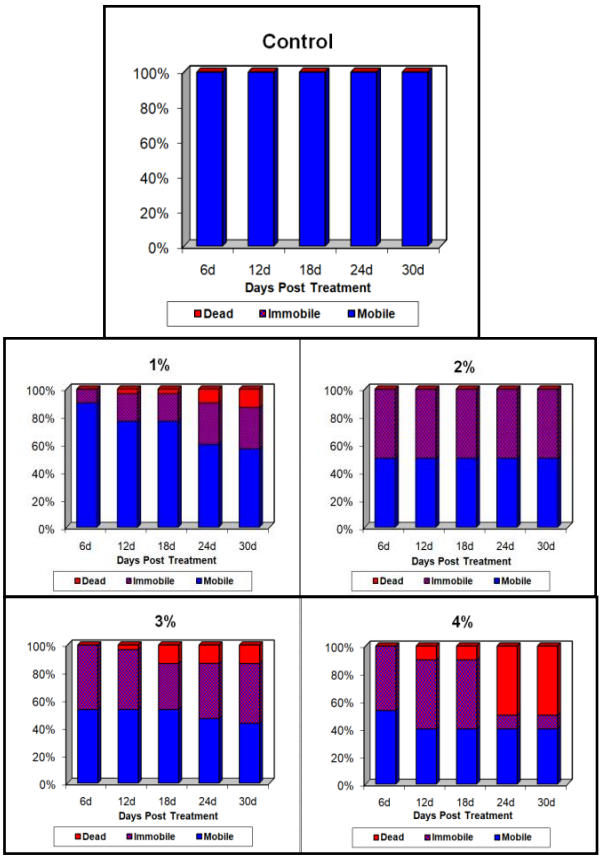

Fig. 4. Effect of methanolic extract of *Funaria hygrometrica* at different concentrations on the mobility and viability of semi-fed female *Argas persicus*.

In general, there was a significant decrease in the percentages of mobile tick females and a significant increase in the percentages of both immobile and dead ones together, in different concentrations of both ethanolic and methanolic extracts of *A. capillus-veneris* and *F. hygrometrica*. Also, the net results showed that methanolic extract (at 4%) was more efficient than ethanolic one for both plants as it recorded 100% efficiency for *A. capillus-veneris* and 50% for *F. hygrometrica* (Fig. 5).

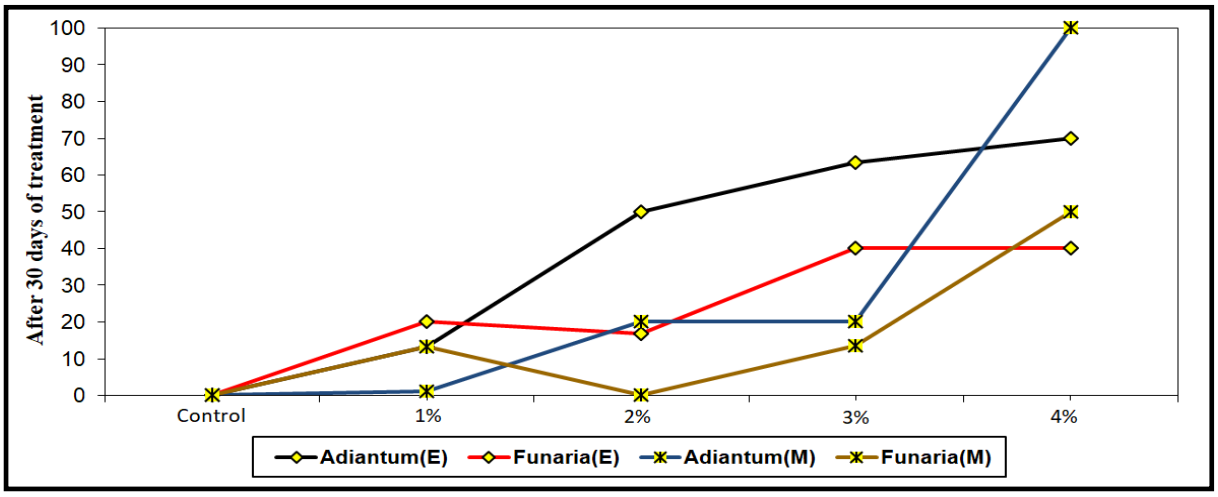

Fig. 5. Effect of ethanolic and methanolic extracts of *Adiantum capillus-veneris* and *Funaria hygrometrica* on the mortality of semi-fed female *Argas persicus* treated with different concentrations after 30 days of treatment.

DISCUSSION

Herbal control is the oldest form of human remedies, plant diseases management, and pesticides known by humans (Al-Snafi, 2015; Srivastava, 2015; Adenubi *et al.*, 2016; Glime, 2017). Nowadays, herbal uses became an integral part of the newly used developed medicine, and pesticides (Al-Snafi, 2015; Adenubi *et al.*, 2016).

Adiantum capillus-veneris L. (Pteridophyta, Polypodiales, Pteridaceae) and *Funaria hygrometrica* Hedw. (Bryophyta, Funariales, Funariaceae) are widespread cosmopolitan plants belong to Cryptogams (plants reproduce by spores, without flowers or seeds) plants (Weitz and Heyn, 1981; Al-Snafi, 2015). Their potentials in medical purposes are well known in either traditional (e.g. Cough, cold, wound healing) or pharmacological uses (e.g. Antimicrobial, antioxidant, neuropharmacological, anti-diabetic, anti-obesity, anti-asthmatic, anti-diarrheal, anti-spasmodic, analgesic and anti-nociceptive, anti-inflammatory and detoxification activities, hypocholesterolemia effect, hair growth-promoting and wound healing properties for *A. capillus-veneris*; pulmonary tuberculosis, hemostasis, hematemesis, bruises, foot dermatophytosis for *F. hygrometrica*), which attributed to their chemical constitutes rich in phenolics, terpenoids, alkaloids, flavonoids, fatty acids, carbohydrates, carotenoids and many other chemicals (Al-Hasan *et al.*, 1990; Al-Snafi, 2015; Rajurkar and Gaikwad, 2012; Asakawa, *et al.*, 2013; Dehdari and Hajimehdipoor, 2018).

Ticks are ectoparasites that transmit many protozoal, viral, and rickettsial diseases that can cause serious harm to animal and human health (Nwanade *et al.*, 2020; Udayan *et al.*, 2020). The high cost, environmental hazards, and development of acaricidal resistance are some of the defects of these chemical acaricides (Udayan *et al.*, 2020) and led to the search for safer and more environmentally friendly alternative methods without compromising efficacy (Nwanade *et al.*, 2020). Plant-based formulations are one of the most promising approaches for controlling ectoparasites (Nwanade *et al.*, 2020; Udayan *et al.*, 2020), including ticks.

The acaricidal efficacy of different plant extracts against different developmental stages of hard ticks have been reported by many acarologists from 1985 to 2014 (e.g. Van Puyvelde *et al.*, 1985; Panella *et al.*, 1997; Al-Rajhy *et al.*, 2003; Pereira and Famadas, 2006; Bagavan *et al.*, 2009; Ravindran *et al.*, 2011; de Mello *et al.*, 2014).

In this regard; several acarologists have studied the effects of alcoholic plant extracts against adult hard ticks such as *Hyalomma anatolicum*, *Rhipicephalus decoloratus*, *R. microplus*, *R. pulchellus*, and *R. turanias* by the immersion method. Whereas, various alcoholic extracts (ethanolic and methanolic) of different parts for numerous plants, e.g. *Acmella oleracea*, *Ageratum conyzoides*, *Aloe rupestris*, *Argemone mexicana*, *Artemisia absinthium*, *Berberis tinctoria*, *Caesalpinia gaumeri*, *Cissus quadrangularis*, *Clematis brachiata*, *Cleome gynandra*, *Dalbergia sissoo*, *Datura metel*, *D. stramonium*, *Dodonaea viscose*, *Eupatorium adenophorum*, *Euphorbia rothiana*, *Neoglaziovia variegata*, *Ficus sycomorus*, *Lobelia leschenaultiana*, *Monsonia angustifolia*, *Pelargonium luridium*, *Semecarpus anacardium*, *Solanum sisymbrifolium*, *Strobilanthes foliosus*, *Schkuhria pinnata*, *Sclerocarya birrea* and *Tabernaemontana elegans*…..etc., recorded 10-100% efficiency against hard ticks within 24 hours to 14 days of treatment (Dantas *et al.*, 2015; Ghosh *et al.*, 2015a, b; Godara *et al.*, 2015, 2018; Banumathi *et al.*, 2016; Cruz *et al.*, 2016; Kumar *et al.*, 2016; Muyobela *et al.*, 2016; Singh *et al.*, 2016; Anholeto *et al.*, 2017; Rosado-Aguilar *et al.*, 2017; Fouche *et al.*, 2017, 2019; Vasconcelos *et al.*, 2018; Figueiredo *et al.*, 2019; Politi *et al.*, 2019; Kemal *et al.*, 2020; Upadhaya *et al.*, 2020). Notably, the ticks killing activity of all extracts increases with increasing concentration and exposure time (Kemal *et al.*, 2020).

On the other hand, there was only one study about the acaricidal effect of the alcoholic plant extracts against the soft ticks (i.e. *Argas persicus*), which was carried out by Massoud *et al.* (2005). Whereas, they recorded 87 and 94 % mortality of female *A. persicus* at the 12th day of dipping them in the extract of Myrrh from *Commiphora molmol* tree at 5 and 10%, respectively.

Despite, in excess of 200 plant species from different countries worldwide have tick-repellent or acaricidal properties utilizing in-vitro tests (Adenubi *et al.*, 2016), but the two studied plants (*A. capillus-veneris* and *F. hygrometrica*) were used for the first time in this approach through the current work.

In the present study, *A. capillus-veneris* extract showed a very good to an excellent efficacy (70% at 4% ethanol extract and 100% at 4% methanol extract) against *A. persicus*. The authors attributed this high efficiency to the containment of *A. capillus-veneris* on thymol (4.05%), carvacrol (13.72%), and L-linalool (0.83%) (Khodaie *et al.*, 2015); which well correlated with their high potential (thymol, carvacrol, and L-linalool) against ticks of 98-100% (Adenubi *et al.*, 2016; Hikal *et al.*, 2017), through their use as active phytochemical constituents against ticks in several countries, e.g. Brazil, India, Iran, Kenya, Turkey and USA (Adenubi *et al.*, 2016; Pavela, 2016; Hikal *et al.*, 2017). Moreover, according to Rajurkar and Gaikwad (2012), *A. capillus-veneris* leaves have phenolics and terpenoids (2.73%), alkaloids (0.53%), fats, and waxes (0.20%) which also have a good acaricidal activity (Adenubi *et al.*, 2016).

From the present work, *F. hygrometrica* extract had a relatively good acaricidal activity (40% at 4% ethanol extract and 50% at 4% methanol extract) which may be returned to one of the two probabilities. The first one is the high containing of glycerolglycolipids (monogalactosyldiacylglycerols, digalactosyldiacylglycerols, sulfoquinovosyldiacyl-glycerols and diacylglycerophosphoglycerols) and fatty acid esters of 1,7-alkanediols (Al-Hasan *et al.*, 1990; Asakawa, *et al.*, 2013; Busta *et al.*, 2016), where they showing acaricidal activities in various countries (e.g. India and Thailand) through in vitro assays (Adenubi *et al.*, 2016). The second possibility is that *F. hygrometrica* (especially sporophyte) contains a relatively high concentration of linolenic acid, one derivative of arachidonic acid, (Al-Hasan *et al.*, 1990; Asakawa, *et al.*, 2013); in addition, tick saliva contains a high concentration of arachidonic acid that facilitates blood meal acquisition (Bowman *et al.*, 1996; Madden *et al.*, 1996) and increased during feeding in their salivary glands (Shipley *et al.*, 1993). So, the authors believe that logically the additional dose of arachidonic acid from *F. hygrometrica* extract enters through the mouthparts of semi-fed *A. persicus* maybe stimulate its ability to feed which leads to their death from starvation because they treated away from their hosts.

Finally, we recommended using herbal pesticides against *Argas persicus* (soft ticks) especially methanolic extract of *Adiantum capillus-veneris* (at 4%), which has all characters of ideal pesticides, i.e. cheap, easily available, biodegradable, or renewable (eco-friendly) and do not cause mammalian toxicity beside their high efficiency which reached to 100%. Also, the authors recommend more tests for both studied plants (*A. capillus-veneris* and *F. hygrometrica*) at different concentrations against other species of pathogenic ticks.

CONCLUSIONS

The present study provided evidence that; at the highest concentration of *Adiantum capillus-veneris* and *Funaria hygrometric* (4%), the percentage of *Argas persicus* semi-fed females' mortality for methanolic extract was more efficient than ethanolic one for both plants. This study is the first one that highlights the acaricidal activity of *A. capillus-veneris* and *F. hygrometric* alcoholic extracts against the ticks generally including *A. persicus*. Results suggest that the acaricidal efficacy of the studied plant extracts may be attributed

to their contents of many active phytochemical constituents that having high potential against ticks.

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ARABIC SUMMARY

الدراسة الأولى لنشاط مبيد القراد من المستخلصات الكحولية *Adiantum capillus-veneris* و*Funaria hygrometric* ضد *Argas persicus*

مي أحمد طه[1] وأسماء علي بيومي علي[2]

1- قسم علم النبات- كلية العلوم- جامعة عين شمس- جمهورية مصر العربية

2- قسم علم الحيوان- كلية العلوم- جامعة عين شمس- جمهورية مصر العربية

أجريت هذه الدراسة للتحقق من نشاط مبيد القراد من المستخلصات الإيثانولية والميثانولية لنباتين من نباتات الكريبتوجام، وهما *Adiantum capillus-veneris* (نبات سرخس) و*Funaria hygrometrica* (نبات حزاز) باستخدام تركيزات مختلفة (1٪، 2٪، 3٪، و4٪) على إناث *Argas persicus* شبه المغتذيات المجمعة من الحقل (بعيدًا عن عوائلها). تم تسجيل النسب المئوية للإناث المتحركة وغير المتحركة والميته كل يومين ولمدة 30 يومًا بعد العلاج مع فحص جميع المستخلصات بالتركيزات المختلفة وذلك باستخدام طريقة الغمس. أشارت النتائج إلى أن جميع المستخلصات بالتركيزات المختلفة تسببت في انخفاض ملحوظ في نسب القراد المتحرك وزيادة ملحوظة في نسب القراد الميتة بالمقارنة مع المجموعة الظابطة. يمكن أن تُعزى فعالية إبادة القراد لمستخلصات *A. capillus-ven*eris و *F. hygrometrica* إلى إحتوائها علي العديد من المكونات الكيميائية النباتية النشطة التي لها كفاءات عالية ضد القراد. عند أعلى تركيز (4٪)، كانت نسبة موت القراد للمستخلص الميثانولي أكثر كفاءة من مثيله الإيثانولي لكلا النباتين، حيث سجلت كفاءة 100٪ لـ *A. capillus-veneris* و 50٪ بالنسبة لـ *F. hygrometrica*. لذلك، فإننا نوصي باستخدام مستخلص الميثانول لـ*A. capillus-veneris* بنسبة 4٪ كمبيد عشبي ضد *A. persicus* والذي يحتوي على جميع خصائص المبيدات المثالية: فَعَّال (كفاءته كمبيد للقراد بنسبة 100٪) ، ومتوفر بسهولة، ورخيص الثمن، وقابل للتحلل (صديق للبيئة) ، ولا يسبب سمية للثدييات.