World Academy of Science, Engineering and Technology
International Journal of Animal and Veterinary Sciences
Vol:8, No:6, 2014

Assessment of Susceptibility of the Poultry Red Mite, *Dermanyssus gallinae* (Acari: Dermanyssidae) to Some Plant Preparations with Focus on Exposure Time

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Open Science Index, Animal and Veterinary Sciences Vol:8, No:6, 2014 publications.waset.org/9998442/pdf

***Abstract*—**Plant preparations from thyme and garlic have been shown to be effective acaricides against the poultry red mite, *Dermanyssus gallinae*. In a layer house with a history of *D. gallinae* problem, mites were detected in the monitoring traps for the first time and number of them was counted. Then, some rows of layer house was sprayed twice using a concentration of 0.21 mg/cm^2 thyme essential oil and 0.07 mg/cm^2 garlic juice and a similar row was used as an untreated control group. Red mite traps made of cardboard were used to assess the mite density during days 1 and 7 after treatment and always removed after 24 h. the collected mites were counted and the efficacy against all mite stages (larvae, nymphs and adults) was calculated. Results showed that on day 1 and 7 after the administration of garlic extract efficacy rate was 92.05% and 74.62%, respectively. Moreover, efficacy rate on day 1 and 7 was 89.4% and 95.37% when treatment was done with thyme essential oil. It is concluded that using garlic juice to control of *D. gallinae* is more effective on short time. But thyme essential oil has a long time effect in compare to garlic preparation.

Keywords*—Dermanyssus gallinae*, Essential oil, Garlic, Thyme, Efficacy.

I. Introduction

THE poultry red mite *Dermanyssus gallinae* (De Geer 1778) is the most important ectoparasite of domestic poultry. Infestations of this mite can result in significant stress to hens with subsequent reductions in condition growth rate, egg quality and production [1]. The poultry red mite has also been implicated as a potential vector of several pathogens [2] including avian spirochetes, chicken pox virus and eastern equine encephalomyelitis [3]. Control of red mite populations worldwide has been provided principally by the use of various contact insecticides such as pyrethroid, organo-phosphorus and carbamate-based acaricides [4]. However, the continued use of these products may be hampered by issues of mite resistance [5], [6], chemical residues in food and undesirable environmental effects [7]. It is therefore becoming increasingly important to use alternative approaches for control of *D. gallinae*. Plant preparations may be an alternative source of materials for mite control because they have a rich source of bioactive chemicals and are commonly used as fragrances and as flavouring agents for food additives [8], [9]. These potential new acaricidal products can be applied to hiding places or host animals in the same manner as the acaricides currently used and much effort has been focused on them and their constituents as potential sources of commercial acaricides [10], [11]. Little information exists with respect to control *D. gallinae* with oriental medicinal plants, although some essential oils such as bay, cade, cinnamon, clove bud and thyme oils are known to possess potent acaricidal activity against this mite species [3].

With this in mind, the aim of the current study was to ascertain the acaricidal potential of plant preparations from garlic and thyme to *D. gallinae* with focus on their exposure time.

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II. Material and Method

A. Farm

The study was performed between January and July 2010 in one commercial egg-producing poultry farm. This farm was selected because of their history of a permanent infestation with *D. gallinae*. This layer house was an aviary system (3 rows) with an outdoor run with a cage system (60 cm of length, 50 cm of width, and 50 cm of height). The house, stocked with 12,800 hens from Hy-Line breed on 36 weeks age. Birds were housed in battery cages with 5 animals per cage and were untreated with acaricide in 3 months recently and the production rate of aviary house was 83%. Flocks were regularly supervised by a veterinarian and clinically examined for infectious and other diseases. Moreover, they were vaccinated against infectious bronchitis and Newcastle disease. Treated and control groups had a minimal 20m distance to prevent of biases in obtained results.

B. Mite Traps

Cardboard traps (150mm by 100mm) (Fig. 1) were used to collect the mites and to assess the intensity of mite infestation. This cardboard trap is described by Meyer-Kuhling et al. (2007) it consists of a double layer of cardboard with a wooden spatula between the two halves, which ensures an even distance of about 2 mm between the two layers [12]. To fix the traps, clamps were used.

In order to prevent of a repellent effect of the glue material, adhesive strips were not used for these traps. At each sampling, 10 traps were placed in the different parts of aviary

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system (totally 90 traps). These positions were: on the floor of nests, at the cross bars, and under the landing perches (Fig. 2). The traps were collected 72 hours after positioning and transferred into plastic bags and labeled with the date of sampling, layer house and trap number and then transported inside a cool box to the laboratory and maintained at -18°C for at least 48 hours, in order to kill mites. Then these mites were transferred into Petri dishes and all trapped mites were weighed using a microgram balance. Then one gram of the mite weight was counted and the total number calculated according to the weight (larval stages, nymphal stages and adult were counted).

C. Plant Essential Oils

Two plant preparations (garlic & thyme) were used in the current work to show a range of toxicities to *D. gallinae*. Thyme essential oil was obtained from Barijeh Esans Co., Ltd., Tehran, Iran. This extract was prepared from thyme plant and has been standard based on 4.4 to 7 mg thymol. Garlic extract was selected from tablet of garlic powder that produced by Amin Pharmacy Co., Ltd., Tehran, Iran. Each garlic tablet had 400 ml dried garlic powder that was equal to 2g fresh garlic. This tablet had more than 1200µg of alicine.

D. Spray Administration

Prior to treatment, 30 traps were placed in different parts of aviary system and after 72 hours positioning, all of them were collected and trapped mite were calculated. It appears that, at a concentration of 0.21 mg/cm^2 thyme essential oil and 0.07 mg/cm^2 garlic juice proved to be highly toxic to *D. gallinae* over 24h [8]. Thereby, it was important to make sure that adequate plant preparations were thoroughly sprayed. Therefore, 3 rows of system were selected and volume of them was calculated. Then, with regard to concentration of each preparation (4.4 to 7mg thymol in each ml of thyme and 1200µg of allicin in each tablet of garlic); necessary emulsion containing plant extracts has been administered per 4 l water. Spray solution was used twice. Meanwhile, during the spray treatment, the hens remained in the cages and were thus exposed to the spray. Before spraying all feeds and eggs were removed. After treatment, traps were placed in same locations with before spraying. The traps were placed on days 1 and 7 after spraying with plant preparations. Then, traps always removed after 24h and all mites in them counted and recorded.

E. Data Analysis

The treatment-associated reduction of the mite numbers (efficacy in %) was calculated:

Mite reduction (efficacy) in % = a – b / a × 100

a: The number of mites/trap untreated control group

b: The number of mites/trap treatment group

Moreover, a *t*-test was used to test for significant differences between treated and control groups with focus on exposure time of plant preparations.

III. Results

A. Garlic

The results of the efficacy trial are shown in Table I as the mean total number of mites after treatment with garlic and thyme oil with focus on exposure time. On day 1 after the administration of garlic extract, the mean total number of trapped mites (larvae, nymphs and adults) decreased to 145.75 ± 29.61 per trap as compared to 1824.61 ± 127.92 mites in the untreated control group. This represents an efficacy of 92.05%. But on day 7 after the spraying, efficacy was 74.62%. The average number of all mite stages per trap on days 1 and 7 after treatment was significantly lower (p<0.05) than before treatment and also in comparison with the control group. But this difference between the mean of counted mites on days 1 and 7 in compare together was not significant (p>0.05).



Fig. 1 Open cardboard trap with accumulation of Mites

B. Thyme

There was significant differences between mean total number of trapped mites on days 1 and 7 after the spraying thyme essential oil in compare to counted untreated control group and mean trapped mite before treatment (p<0.05). The mean total number of trapped mite on 1 day after spraying was 200.25 ± 24.91 and efficacy rate was 89.4%. Moreover, this rate increased in day 7 after treatment (95.37%). There was no significant difference in acaricidal activity of thyme oil on days 1 and 7 after treatment (p>0.05).

IV. Discussion

Infections with *D. gallinae* resulted in reduced weight gain, anaemia and even death of some of the hens. Behavioural changes were also observed, as the mite infected hens showed higher self-grooming and head scratching both during the day and night [4]. Some plant preparations have potential as products for *D. gallinae* control because some of them are selective and have little or no harmful effects on non-target organisms [3]. The aim of this study was to evaluate the repellent properties and to assess the toxicity of plant-derived products to *D. gallinae*.

Results in the present study showed that both of the plant preparations; garlic and thyme were effective in the control of poultry red mite and their efficacy rates were 92.05% and

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89.4% on day 1 after the spraying, respectively. Plant preparations may be achieved as combining application with other control strategies in an integrated pest management approach, though combining control options may not led to overall efficacy [13], [14]. The acaricidal activity of 56 plant essential oils including; bay, cade, cinnamon, clove bud, coriander, horseradish, lime, mustard, pennyroyal, pimento berry, spearmint, thyme red and thyme white oils against poultry red mite was observed [3]. The results of a study also showed that certain eucalyptus essential oils may be of use as an alternative to synthetic acaricides in the management of the mite [1]. Garlic is often used in folk medicine. Birrenkott et al. (2000) showed that repeated topical applications of garlic juice (10%) on hens heavily infested with the Northern fowl mite, *Ornithonyssus sylviarum* significantly reduced the level of infestation. In another study, spraying in each week for 3 wk with a 10% garlic juice solution significantly decreased the incidence of northern fowl mites at 4 and 8 wk following start of treatment [15]. The authors suggest that this effect mainly due to a repellent effect preventing re-infestation and not to direct acaricidal effects. But in another study were shown direct effects of garlic juice on oviposition and survival of the closely related species *D. gallinae*. This indicates that fresh garlic juice can have both, direct and indirect effects on mites. But this remains unclear whether garlic oil has the same insecticidal properties as fresh juice [14]. So totally, garlic is known to be an effective insecticide, acting on adult [16]. In another study, pure garlic juice was the only plant preparation which quickly killed *D. gallinae*. It appears that before garlic can be considered as a component of a strategy against *D. gallinae*, the question of conservation and standardization of the crude extract has to be solved [14].

Thyme essential oil also displayed a favorable rate of red mite knock-down in comparison to the other alternative control methods [8]. Other study suggested that some essential oils were repellent to some degree and thyme essential oil may be especially useful in mite management as it was found to remain repellent to adult mites for up to 13 days. Findings showed that this oil was one of the most highly toxic oils, where exposure to thyme essential oil provided 100% mite mortality [10]. At a concentration of o.21 mg/cm^2 thyme essential oil proved to be highly toxic to *D. gallinae* over 24 h. Cade essential oil was significantly less toxic over the same period [13]. George et al. (2009) showed that thyme essential oil was the most effective in comparison to other six essential oils tested (manuka, palmarosa, caraway, spearmint, black pepper and juniper leaf). Research has shown that essential oil products work to disrupt binding of invertebrate nerve cord proteins, specifically ^{3}H-octopamine. These findings suggest that plant oils could be selected for development that, whilst repellent to *D. gallinae*, would have a minimal effect on non-target organisms if employed as pesticides/repellents in poultry systems against mites, lice, bedbugs, fleas, ticks and various species of Diptera [6]. Thyme essential oil, for example, has been identified as being relatively highly toxic to *D. gallinae* and thymol, its main constituent, was effective against another parasitic mite *Psoroptes cuniculi* [17]. Another study showed that thyme essential oil would have a minimal impact on non-target invertebrates, whilst serving as a pesticide for *D. gallinae* [6]. Vertebrates do not possess octopaminergic nervous systems and this may account for the low mammalian toxicity of essential oils [13]. In contrast, another study showed that not all essential oils were as toxic to some non-target invertebrates as they were to poultry red mite, suggesting that it may be possible to select certain oils for development as acaricides against *D. gallinae* that would have minimal impact on non-target organisms [13].



Fig. 2 Cardboard trap fixed at the floor in the aviary system

This study showed that in the treatment group with garlic, spraying led to significant decrease in number of *D. gallinae* population (92.5%). But on day 7 after spraying mite population increased. In contrast, in the treated group with thyme, number of mites decreased to 89.4% and 95.37% after 1 and 7 day. So, efficacy rate in thyme essential oil was increased after 7 days and there is this probability that effect of thyme essential oil is longer than garlic extract. Investigation on mode of action of plant preparations is important because it may give useful information on the most appropriate formulation and delivery means. Volatile compounds of many plant extracts are composed of alkanes, alcohols, aldehydes and terpenoids, particularly monoterpenoids, and exhibit fumigant activity [18]. It appears that chemical compositions of essential oils may be effect on the acaricidal activity of them. Researches showed that essential oils that were composed of the fewer chemical components were the least lethal to *D. gallinae*. It may therefore be the case that the complexity of an essential oil's chemical make up plays an important role in dictating the toxicity of that oil to mite [1]. It is hypothesized that variation resulted from the use of different batches of essential oils, which could have varied in chemistry formulations and hence acaricidal activity [8], [14]. In an experiment where mites were allowed contact with the essential oil in either open or closed farms, mortality was always reduced in the open where this was comparable to control mortality for thyme essential oils treatment [8], [14]. It has suggested by Kim et al. (2003 and 2007) that the mode of toxic action of plant essential oils against *D. gallinae* is fumigant [11], [18]. Acaricidal activity

of thyme essential oil is due to the high concentration of thymol present in this oil, which has been developed for commercial use against parasitic bee mite species [9]. Studies demonstrated that when mites were exposed to only the vapor phase of the essential oil without contact with oil itself, mortality was consistently higher in closed fields than in farms open to the surrounding environment and suggest that all three essential oils were toxic to *D. gallinae* by fumigant action [10]. It remains to be shown that thyme essential oil displays residual toxicities to *D. gallinae* as low as those found with other essential oils. Moreover, it suggests that red mites are more susceptible to the effects of plant preparations after starving for 3 weeks than recently fed mites. These results indicate that the route of action for the oils was largely in the vapour phase via the respiratory system, although the exact mode of action of them remains unknown [1].

In conclusion, some plant preparations described herein may be useful as mite control sprays for *D. gallinae*. Further research is necessary on safety issue of these plants on human health and acaricidal constituents of the plants.

TABLE I
THE RESULTS OF THE EFFICACY TRIAL OF GARLIC AND THYME ESSENTIAL OIL IN CONTROL OF RED MITE WITH FOCUS ON EXPOSURE TIME

	1 DAY BEFORE TREATMENT	1 DAY AFTER TREATMENT	7 DAYS AFTER TREATMENT
GARLIC	1805.75 ± 193.52	145.75 ± 29.61	455.50 ± 64.52
THYME	1741.63 ± 201.67	200.25 ± 24.91	83.13 ± 8.87
CONTROL	1782.63 ± 141.86	1824.61 ± 127.92	1793.84 ± 183.06

REFERENCES

[1] D. R. George, D. Masic, O. A. E. Sparagano, J. H. Guy, "Variation in chemical composition and acaricidal activity against *Dermanyssus gallinae* of four eucalyptus essential oils" J. Exp. Appl. Acarol., vol. 48, no. (1-2), pp. 43-50, 2008.

[2] J. Chirico, H. Eriksson, O. Fossum, D. Jansson, "The poultry red mite, *Dermanyssus gallinae*, a potential vector of *Erysipelothrix rhusiopathiae* causing erysipelas in hens". Med. Vet. Entomol., vol. 30, pp. 281-285, 2003.

[3] E. H. Kim, H. K. Kim, Y. J. Ahn, "Acaricidal activity of clove bud oil compounds against *Dermatophagoides farinae* and *Dermatophagoides pteronyssinus* (Acari: Pyroglyphidae)". J. Agric. Food Chem., vol. 51, 885-889, 2003.

[4] A. Keita, E. Pagot, P. Pommier, L. Baduel, J. Heine, "Efficacy of Phoxim 50% E.C. (ByeMite) for treatment of *Dermanyssus gallinae* in laying hens under field conditions" Revue Med. Vet., vol. 157, no. 12, 590-594, 2006.

[5] M. D. Fiddes, S. Le Gresley, D. G. Parsons, C. Epe, G. C. Coles, K. A. Stafford, "Prevalence of the poultry red mite (*Dermanyssus gallinae*) in England". Vet. Rec., vol. 157, 233-235, 2005.

[6] D. R. George, O. A. E. Sparagano, G. Port, E. Okello, R. S. Shiel, J. H. Guy, "Repellence of plant essential oils to *Dermanyssus gallinae* and toxicity to the non-target invertebrate *Tenebrio molitor*" Vet. Parasitol., vol. 162, 129-134, 2009b.

[7] J. P. Dalton, G. Mulcahy, "Parasite vaccines-a reality?" Vet. Parasitol., vol. 98, 149-167, 2001.

[8] R. D. George, G. Olatunji, J. H. Guy, O. A. E. Sparagano, "Effect of plant essential oils as acaricides against the poultry red mite, *Dermanyssus gallinae*, with special focus on exposure time". Vet. Parasitol., Article in press, 2010a.

[9] Z. Ghrabi-Gammar, D. R. George, A. D. Bouattour, I. B. Haj Jilani, S. B. Saad-Limam, O. A. E. Sparagano, "Screening of essential oils from wild-growing plants in Tunisia for their yield and toxicity to the poultry red mite, *Dermanyssus gallinae*". Industry Crops Prod., vol. 30, 441-443, 2009.

[10] D. R. George, T. J. Smith, R. S. Shiel, O. A. E. Sparagano, J. H. Guy, "Mode of action and variability in efficacy of plant essential oils showing toxicity against the poultry red mite, *Dermanyssu gallinae*". Vet. Parasitol., vol. 161, 276-282, 2009a.

[11] L. K. Kim, Y. E. Na, J. H. Yi, B. S. Kim, Y. J. Ahn, "Contact and fumigant toxicity of oriental medicinal plant extract against *Dermanyssus gallinae* (Acari: Dermanyssidae)". Vet. Parasitol., vol. 145, 377-382, 2007.

[12] B. Meyer-Kuhling, J. Heine, J. Muller-Lindloff, K. Pfister, "Epidemiology of *Dermanyssus gallinae* and acaricidal efficacy of Phoxim 50% in alternative housing systems during the laying period of hens". Parasitol. Res., vol. 101, 1-12, 2007.

[13] D. R. George, O. A. E. Sparagano, G. Port, E. Okello, R. S. Shiel, J. H. Guy, "Toxicity of plant essential oils to different life stages of the poultry red mite, *Dermanyssus gallinae*, and non-target invertebrates" Med. Vet. Entomol., no. 24, 9-15, 2010b.

[14] V. Maurer, E. Perler, F. Heckendorn, "*In vitro* efficacies of oils, silicas and plant preparations against the poultry red mite *Dermanyssus gallinae*". J. Exp. Appl. Acarol., vol. 48, no. (1-2), 31-41, 2009.

[15] G. P. Birrenkott, G. E. Brockenfelt, J. A. Greer, M. D. Owens, "Topical application of garlic reduces northern fowl mite infestation in laying hens". Poult. Sci., vol. 79, 1575-1577, 2000.

[16] R. Dhar, H. Dawar, S. Garg, S. F. Basir, G. P. Talwar, "Effect of volatiles from neem and other natural products on gonotrophic cycle and oviposition of *Anopheles stephensi* and *An. Culicifacies* (Diptera: Culicidae)". J. Med. Entomol., vol. 33, 195-201, 1996.

[17] S. Perrucci, G. Macchioni, P. L. Cioni, G. Flamini, I. Morelli, "Structure/activity relationship of some natural monoterpenes as acaricides against *Psoroptes cuniculi*". J. Nat. Prod., vol. 58, 1261-1264, 1995.

[18] S. I. Kim, J. H. Yi, J. Tak, Y. Ahn, "Acaricidal activity of plant essential oils against *Dermanyssus gallinae* (Acari: Dermanyssidae)". Vet. Parasitol., vol. 120, 297-304, 2004.

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