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Acaricidal effect of eleven essential oils against the poultry red mite *Dermanyssus gallinae* (Acari: Dermanyssidae)

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Abstract. The acaricidal effect of eleven essential oils (Sweet basil, Common juniper, Atlas cedar, Coriander, Blue gum, European silver fir, Common lavender, Lemon, Peppermint, Scots pine, Summer savory) against poultry red mite *Dermanyssus gallinae* was tested *in vitro* using the direct contact method, at three different doses: 0.2 mg/cm^2, 0.4 mg/cm^2 and 0.6 mg/cm^2. The results of the study revealed that oils of sweet basil, coriander, peppermint and Summer savory were the most effective.

Keywords: *Dermanyssus gallinae;* Essential oils; Layers; Transylvania; Romania.

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Introduction

In the last years, *Dermanyssus gallinae* infestation represents a major problem in poultry industry; the economic and animal health impact are important and farmers need adequate therapeutic measures to control this parasite (Meyer-Kühling et al., 2007; Roy et al., 2009; Sparagano et al., 2009). This blood-feeding mite causes production losses due to irritation and anemia, but may even cause death of its host and is also involved in transmission of many pathogenic agents responsible for severe outbreaks in both animals and humans (Chirico and Tauson, 2002; Valiente Moro et al., 2009). With this view, there is constant need for alternative control measures to maintain a good animal health in aviary systems.

The most common form to control *D. gallinae* infestation worldwide rely mostly on the use of various synthetic contact acaricides such as permethrin, carbaryl, diazinon, dichlorvos, which although effective, their repeated use leads often to the development of resistance and further, the residues in eggs and meat are a highly important problem for human health (Kim et al., 2007). Issues like the icreased resistance to some synthetic acaricides, legislative changes that promote open system rearing instead of conventional caging will make that in the near future many more of the world's 2.8 billion laying hens (11.7% of which are located in the EU) to suffer as a result of *D.*

gallinae infestation if alternatives to synthetic acaricides are not sought (George et al., 2010). Acaricide/insecticide activity of some plant extracts was used in Asia, since thousand years ago. On global level, issues related to drug chemical pollution, through the accumulation of residues with active potential (mutagenic, carcinogenic, teratogenic) in products from animals treated with antiparasitic synthetic molecules are increasingly studied (Cernea, 2006). Route avoidance of these drawbacks could be the use of vegetable organic pharmaceuticals (Lee et al., 1997). Plant essential oils may be an alternative source of products used in the treatment of mite infestations, because they are rich sources of bioactive chemicals and are commonly used as fragrances and as flavoring agents for food additives (Kim et al., 2004). Use of medicinal plants is currently seen as an alternative transition from empirical to scientific phytotherapy, plants representing a remarkable economic potential source with broad possibilities for development and implementation. Application of phytotherapy in veterinary practice is offering the development of therapeutic area and, in combination with other approaches, provides a higher level of safe therapy, treating carefully animals, men and environment.

The aim of the present study was to test the *in vitro* acaricidal potential of 11 essential oils on *D. gallinae,* using the direct contact method.

Materials and methods

Researches performed on *D. gallinae* mites collected from five farms of layers using caging system, from three different counties of Transylvania, Romania. Mites were collected from bird cages with the aid of a brush in plastic jars and were used for tests within 2 days of collection. Until testing, the mites were kept at 24 C° under a photoperiod of 16:8 h (light/dark). We have used for tests 11 vegetal extracts shown in table 1.

Essential oils were used at a rate of 0.2 mg/cm^2, 0.4 mg/cm^2, and 0.6 mg/cm^2; dilution was made in ethanol. Strips of filter paper with the dimension of 10/100 mm were impregnated with essential oils at rate of 10 µl suspension/cm^2. After storage in a fume cupboard to allow the evaporation of ethanol, the strips were introduced in Pasteur pipettes, and 20 mites (adult females of *D. gallinae*) were then introduced in each pipette by means of a vacuum pump. Three filter paper strips were impregnated for each concentration and three additional strips were impregnated with ethanol and dried, representing the controls. All the pipettes were stored at dark and mortality was determined at 24, 48 and 72 hours of contact, under stereomicroscope. Mites were considered dead if no movement was observed at repeated agitation of the pipettes.

Table 1. Vegetal extracts tested on *D. gallinae* mites collected from 5 layer farms

Common name (Abbreviation)	Latin name
Sweet basil (SB)	*Ocimum basilicum*
Common juniper (CJ)	*Juniperus comunis*
Atlas cedar (AC)	*Cedrus atlantica*
Coriander (C)	*Coriandrum sativum*
Blue gum (BG)	*Eucalyptus globulus*
European silver fir (ESF)	*Abies alba*
Common lavender (CL)	*Lavandula angustifolia*
Lemon (L)	*Citrus limon*
Peppermint (P)	*Mentha* x *piperita*
Scots pine (SP)	*Pinus sylvestris*
Summer savory (SS)	*Satureja hortensis*

Standard deviation (SD) was calculated using software Statistica 9.0 (StatSoft ®).

Results

Acaricidal effect of the 11 essential oils against *D. gallinae* mites, at different oils dose is shown in table 2.

For the dose 0.2 mg/cm^2 of essential oils, after 24 hours of contact, a very low efficacy was recorded for lemon (3.3%) and European silver fir (5%). Best efficacy after 24 hours of contact, with >90% mortality was recorded fort the oils of sweet basil 0.6 mg/cm^2, coriander 0.4 and 0.6 mg/cm^2, peppermint 0.6 mg/cm^2 and summer savory 0.6 mg/cm^2.

After 48 hours of contact, mortality >90% was recorded for the oils of sweet basil tested at 0.6 mg/cm^2, coriander 0.4 and 0.6 mg/cm^2, Blue gum 0.6 mg/cm^2, lavender 0.6 mg/cm^2,

peppermint 0.4 and 0.6 mg/cm^2, summer savory 0.4 and 0.6 mg/cm^2.

Mortality was > 90% after 72 hours of contact for the extracts of basil 0.4 and 0.6 mg/cm^2, Atlas cedar 0.6 mg/cm^2, coriander 0.4 and 0.6 mg/cm^2, blue gum 0.6 mg/cm^2, lavender 0.4 and 0.6 mg/cm^2, peppermint at all the concentrations and summer savory 0.4 and 0.6 mg/cm^2. A low efficacy, with mortality <50% after 72 hours of contact was recorded at the extracts of common juniper 0.2 and 0.4 mg/cm^2, European silver fir 0.2 mg/cm^2, lemon 0.2 and 0.4 mg/cm^2 and Scots pine 0.4 mg/cm^2.

Table 2. Acaricidal effect of the 11 essential oils against *D. gallinae* collected from 5 layers farms

Essential oil	Dose*	Average mortality (%) (mean ± SD)		
		24 h	48 h	72 h
SB	0.2	51±2.2	65±5.3	75±3.1
	0.4	77.6±2.5	86.6±5	96.6±3.6
	0.6	100±0.0	100±0.0	100±0.0
CJ	0.2	12.3±5.6	26.6±4.3	43.3±3.6
	0.4	8.3±6.1	25±8.6	45±2.2
	0.6	13.3±5.2	28.3±2.5	55±1.2
AC	0.2	26.6±4.9	71.6±4.3	81.6±3.1
	0.4	38.3±4.7	85±2.3	88.3±2.3
	0.6	41.6±10.1	83.3±2.7	91.6±1.1
C	0.2	56.6±11.4	83.3±2.1	90±1.1
	0.4	100±0.0	100±0.0	100±0.0
	0.6	100±0.0	100±0.0	100±0.0
BG	0.2	30±6.1	73.3±4.3	80±2.3
	0.4	51.6±4.2	78.3±4.1	81.3±2.3
	0.6	80±3.4	93.3±2.7	100±0.0
ESF	0.2	5±3.5	13.3±2.8	26.6±8.2
	0.4	15±3.5	26.6±3.5	55±8.2
	0.6	13.3±2.8	23.3±4.3	50±11.2
CL	0.2	18.3±8.1	50±6.1	78.3±3.9
	0.4	38.3±4.1	71.6±3.7	93.3±2.3
	0.6	61.6±2.2	98.3±2.1	98.3±1.2
L	0.2	3.3±2.3	8.3±3.1	16.6±2.4
	0.4	8,3±2.4	18.3±3.1	36.6±2.2
	0.6	11.6±2.4	18.3±2.4	65±2.5
P	0.2	53.3±9.8	85±4.2	93.3±1.7
	0.4	55±6.3	98.3±3.1	100±0.0
	0.6	96.6±3.1	100±0.0	100±0.0
SP	0.2	21.6±4.6	40±3.9	58.3±3.7
	0.4	25±4.1	33.3±3.1	46.6±8.6
	0.6	26.6±3.7	35±2.7	76.6±2.9
SS	0.2	56.6±5.6	66.6±3.3	76.6±2.2
	0.4	90±3.4	100±0.0	100±0.0
	0.6	100±0.0	100±0.0	100±0.0
Control		0	0	3.3

* mg/cm^2 essential oils

Discussions

Many essential oils are known to have various efficacies such as ovicidal, repellent, anti-feeding or other biocidal activities against various parasitic arthropods (Isman, 1999). A 92% reduction of *D. gallinae* populations was recorded after testing cardboard traps containing 20% neem oil (*Azadirachta indica*) in a floor system for layers by Lundh et al. (2005). Pure garlic (*Allium sativum*) juice and Chrysanthemum (*Chrysanthemum cinerariae-folium*) high concentration extract were found effective against *D. gallinae* by Maurer et al. (2009).

The acaricidal activity of methanolic extracts from 40 oriental medicinal plant species and a steam distillate of Camphor tree (*Cinnamomum camphora*) against *D. gallinae* was tested by Kim et al. (2007), the results showing *C. camphora* steam distillate to be the most toxic, followed by extracts from *Asarum sieboldii* var. *seoulens*, *Eugenia caryophyllata* and *Mentha arvensis* var. *piperascens*. The acaricidal activity of some plant extracts was almost comparable to that of some synthetic acaricides like profenofos, benfuracarb, prothiofos, propoxur and fenthion. Kim et al. (2004) reported 100% mortality on *D. gallinae* after testing bay, cade, cinnamon, clove bud, coriander, horseradish, lime, mustard, pennyroyal, pimento berry, spearmint, red thyme and white thyme essential oils at 0.07 mg/cm^2. Comparing our results for some of the extracts what these authors tested, for the extracts of coriander and summer savory we obtained the same 100% mites mortality after 24 hours of contact, but at the dose of 0.4 and 0.6 mg/cm^2 respectively. Results were different for the extracts of common juniper, Atlas cedar, blue gum, European silver fir, common lavender, and lemon for which previous authors noted 100% mortality at the dose of 0.35 mg/cm^2, and our studies revealed a mortality of the mites between 8.3-51.6% at the dose of 0.4 mg/cm^2.

Testing four species of the genus *Eucalyptus* (*E. citriodora, E. radiata*, *E. globulus* and *E. staigeriana*), George et al. (2009) found *E. citriodora* as the most effective, with 85% mortality in *D. gallinae* over a 24 h exposure period in contact toxicity tests. *E. globulus* and

E. radiata, provided significantly lower mite mortality (11 and 19%, respectively). Also notable differences were found between the *Eucalyptus* essential oils regarding their chemical compositions. In our study, we found an efficacy of *E. globulus* essential oil between 30-80% after 24 hours of contact, depending on the dose. Differential susceptibility of adult *D. gallinae* to the essential oils from the same plant genus was also observed by Kim et al. (2004) for seven *Citrus*, three *Cymbopogon*, two *Eucalyptus*, two *Juniperus*, three *Mentha*, two *Origanum* and two *Pimenta* species. Numerous factors like geographic origin, seasonality, method of oil extraction, year of harvest and even storage conditions can affect the composition of essential oils, so the results from different toxicity studies might not always be the same (Chalchat et al., 2007; Flamini and Cioni, 2007; Raal et al., 2007). This could explain the differences in efficacy for the essential oils we tested, comparing with the studies of other authors.

Compounds of plant origin could represent a valid alternative to synthetic drugs and indeed, in recent years, several studies have reported acaricidal activity of natural plant extracts against *Psoroptes cuniculi*, *Varroa destructor*, *Acarapis woodi*, *Dermatophagoides farinae* and *D. pteronyssinus* (Miyazki et al., 1989; Watanabe et al., 1989; Imdorf et al., 1999; Rice et al., 2002; Macchioni et al., 2004). George et al. (2010) tested 7 essential oils (manuka, cade, pennyroyal, thyme, garlic, clove bud and cinnamon bark) previously found to be effective adulticides against *D. gallinae,* on two model non-target species, the brine shrimp, *Artemia salina* and the mealworm beetle, *Tenebrio molitor*. Results showed that not all essential oils were as toxic to *A. salina* and *T. molitor* as they were to *D. gallinae*, excepting garlic. Variation seen in the toxicity of selected essential oils to *A. salina* and *T. molitor* is favorable to the development of these essential oils as acaricides for use against *D. gallinae* in poultry systems, based also on their minimal impact on non-target organisms.

Variation in essential oil chemistry has been identified as an issue that might need to be addressed if such products are to be reliably used in pest management (Isman, 2008). Essential oils with complex chemical compositions may have an additional advantage over simpler oils if they are used as pesticides. As a benefit of such products if they are used for pest management would be that the numerous active compounds in essential oils would make development of pest resistance to any essential oil-based product extremely difficult (Miresmailli et al., 2006).

However, when selecting an essential oil to develop it in use for *D. gallinae* control, care must be taken, because of their inconsistence in efficacy. On the other hand, because certain plant extracts and essential oils meets the criteria of minimum risk pesticides, much effort must be focused on them and their constituents as potential sources of commercial acaricides.

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