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Revisión | Review

Acaricidal and insecticidal effects of essential oils against ectoparasites of veterinary importance

[Efectos acaricidas e insecticidas de los aceites esenciales contra los ectoparásitos de importancia veterinaria]

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Abstract: Ectoparasitism in animals has become an issue of great concern that needs to be resolved to prevent huge economic losses occurring to livestock industry all over the world. Synthetic adrugs have been playing a major role in controlling ectoparasites, but their frequent and irrational use has resulted in drug resistance to routinely used chemicals and their residual effects on food and environment. Therefore, this approach of using chemical acaricides and insecticides is losing its popularity and effectiveness in controlling ectoparasites. So, the development of alternative approaches in ectoparasite management is currently required. Among alternative protocols, plants and their essential oils have played remarkable role in controlling different ectoparasites (ticks, flies, mites, lice) of veterinary importance. Essential oils have been proved to be cheaper, more effective and safer therapeautic agents against different ectoparasites of livestock importance.

Keywords: Plants; Essential oils; Ectoparasites; Animals

Resumen: En los animales el ectoparasitismo se ha convertido en un tema de gran preocupación que debe resolverse para evitar que se produzcan grandes pérdidas económicas para la industria ganadera en todo el mundo. Los aditivos sintéticos han desempeñado un papel importante en el control de los ectoparásitos, pero su uso frecuente e irracional ha dado como resultado la resistencia a los fármacos utilizados habitualmente y efectos residuales sobre los alimentos y el medio ambiente. Por lo tanto, el enfoque basado en el uso de acaricidas e insecticidas químicos está perdiendo popularidad y efectividad en el control de los ectoparásitos. Por lo tanto, actualmente se requiere el desarrollo de enfoques alternativos en el manejo de ectoparásitos. Entre los protocolos alternativos, las plantas y sus aceites esenciales han jugado un papel notable en el control de diferentes ectoparásitos (garrapatas, moscas, ácaros, piojos) de importancia veterinaria. Se ha demostrado que los aceites esenciales son agentes terapéuticos más baratos, más efectivos y más seguros contra diferentes ectoparásitos de importancia ganadera.

Palabras clave: Plantas; Aceites Esenciales; Ectoparásitos; Animales

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INTRODUCTION

Parasitic diseases account for important health hazard in man and animal in tropical countries. Ectoparasites cause serious threat to animalshealth and economy all over the world. They can cause annoyance, irritation, skin infection, anaemia, tick fever as well as act as a vector for various devastating diseases of livestock importance (Abbas *et al.,* 2014; Yadav *et al.,* 2017). Among ectoparasites, tickborne infections are recognized as most devastating because of causing huge economic losses (Chen *et al.,* 2014; Demessie and Derso, 2015; Opara *et al.,* 2016). Likewise, ectoparasites are of great concern due to their increasing prevalence, zoonotic potential and causing lowered animal productivity (Jabbar *et al.,* 2015; Zahid *et al.,* 2016; Zaman *et al*., 2017a; Zaman *et al*., 2017b).

Ectoparasites infecting various species of animals are controlled by using synthetic insecticides which is mostly practiced method throughout the world in spite of several problems like development of resistance, public concern in terms of residue in food and environment pollution (Maxwell *et al.,* 2002; El-Seedi *et al.,* 2017; Showler, 2017). Therefore, use of insecticides has been limited due to development of insecticidal drug resistance in ticks (Olivares-Pérez *et al.,* 2011; Foil *et al.,* 2004; El-Seedi *et al.,* 2017), lice (Ellse *et al.,* 2012), flies (Showler, 2017) and mites (Beugnet *et al.,* 1997).

Due to resistance problems alternative options are being incorporated in strategic and integrated parasite control programs (Masood *et al.,* 2013; Abbas *et al.,* 2017a; Abbas *et al.,* 2017b; Idris *et al*., 2017; Khan *et al*., 2017). Among alternatives, the use of essential oils has been an area of focused research in several countries (Álvarez *et al.,* 2008; Khaliq *et al.,* 2015; Liaqat *et al.,* 2016).

Plants extracts and essential oils have been extensively used in controlling diseases of parasitic, viral and bacterial origin (Ibrahim *et al.,* 2001; Ntalli *et al.,* 2010; Ellse *et al.,* 2013; Ellse & Wall, 2014; Aslam *et al*., 2016; Awaad *et al.,* 2016; Chen *et al*., 2016; Fang *et al*., 2016; Sands *et al.,* 2016; Esmacily *et al*., 2017; Radsetoulalova *et al*., 2017; Sharifi-Rad *et al*., 2017).

Herbal medication has become an appealing approach and it has gained great importance in tropical and subtropical regions especially in Asia and Africa (Habeeb, 2010; Fang *et al.,* 2016; Ijaz *et al.,* 2016; Rehman *et al*., 2016; Niroumand *et al*., 2016; Showler, 2017; Qureshi *et al*., 2017). Scientists and researchers all over the world have proved that the phytochemicals or essential oils obtained from different plants have ovicidal, larvicidal, adulticidal and repellent effects against ectoparasites (Abbas *et al.,* 2014; Fang *et al.,* 2016). Efficiency of botanical driven products and essential oils is frequently ascribed due to their main constituents which have diverse properties and positive effects (Yang *et al.,* 2003; Cal, 2006; Birkett *et al.,* 2011; Abbas *et al.,* 2014; El-Seedi *et al.,* 2017).

This review estimates the potential essential oils in controlling ectoparasites of veterinary importance with their possible mechanism of action.

Effects against Ticks

A lot of work has been done in last decade on investigating the acaricidal response of different essential oils against ticks of *Ixodidae* family (hard ticks). Essential oils of *Ageratum houstonianum* have shown remarkable effects against ticks biting goats.There was a 94.9% decrease in the counting of biting ticks on goats treated with essential oils of *Ageratum houstonianum* (Pamo *et al.,* 2005). In an *in vitro* experiment essential oils derived from *Thymus vulgaris, Dorystoechas hasata* and *Mentha longifolia* were tested through larval immersion test which resulted in 99% mortality of *Rhipicephalus microplus* larvae after exposure to eachoil (0.1% soultion) (Koc *et al.,* 2013). Essential oils of *Pimenta dioica* and *Cuminum cyminum* were also effective against *Rhipicephalus microplus* in 1.26% and 2.49% solution of each oilwhile essential oil of *Ocimum basilicum* had no larvae killing possessions, even at the quantity of 19.9% (Martinez-Velazquez *et al.,* 2011). Essential oil of *Hypericum polyanthemum* (Ribeiro *et al.,* 2007) and *Calceolaria serrata* (Ribeiro *et al.,* 2008) caused no effect on mortality of two species of ticks including *Rhipicephalus sanguineus* and *Rhipicephalus microplus*. In another study, the essential oils of *Melaleuca alternifolia* (Iori *et al.,* 2005), *Satureja thymbra* (Cetin *et al.,* 2010) and *Origanum minutiflorum* (Cetin *et al.,* 2009) were proved to be effective against hard ticks.

In a recent *in vitro* study, essential oils of *Conyza dioscoridis, Artemisia herba-alba* and *Calendula officinalis* have shown high repulsive activity against hard ticks (El-Seedi *et al.,* 2017). In another *in vivo* study protective action of *Tagetes minuta* (*Asteraceae*) essential oil against *Rhipicephalus microplus* was reported and results suggested that *Tagetes minuta* was greatly effective

against ticks (Andreotti *et al.*, 2013). Previously, essential oil of *Tagetes minuta* essential oil proved to be 95% effective for controlling the different tick species including *Rhipicephalus microplus*, *Rhipicephalus sanguineus*, *Amblyomma cajennense* and *Argas miniatus*. The efficacy of essential oil was accesssed by adult immersion and larval packet tests (Garcia *et al.*, 2012).

The acaricidal potential of essential oils may be accredited due to the action of their volatile components and constituents (Kim *et al.*, 2007; George *et al.*, 2009; Cetin *et al.*, 2010).

Effects against Mites

Essential oils are also effective against various mites infecting animals. In an *in vitro* study, the essential oils of plants such as *Eugenia caryophyllata*, *Coriandrum sativum* and *Juniperus oxycedrus* were proved to be effective against *Dermanyssus gallinae* (poultry red mite) and caused 99.9% mortality (Kim *et al.*, 2004). In a recent study, essential oils derived from plants such as clove, palmarosa, tea tree, and *eucalyptus* species have shown potential against *Sarcoptes scabiei* (Itch mite). Results of study demonstrated that essential oils of these plants are potential alternative products to treat *Sarcoptes scabiei* infections in animals and humans (Fang *et al.*, 2016).

In another trial in which mites were permittedinteraction with essential oil of *Leptospermum scoparium* in closed and open chambers which showed good results by causing 29.9% mortality rate in open chambers while 80% mortality rate in closed chambers (George *et al.*, 2009). Likewise, higher mortality was observed after treatment of essential oil of *Thymus vulgaris* in closed chambersas compared to open chambers (George *et al.*, 2009). It has been shown that volatile characteristics in *Thymus vulgaris* may be enough to resist *Dermanyssus gallinae* for up to 10-15 days (George *et al.*, 2009). Essential oil of *Lavandula angustifolia* caused 70% mortality of mites in an *in vitro* assay (George *et al.*, 2008).

Some other *in vitro* studies have demonstrated that essential oil of *Lavandula angustifolia* and most of its ingredients have shown potential against *Psoroptes cuniculi* (Perrucci *et al.*, 1996). Furthermore, essential oil of *Cinnamomum verum* (cinnamon) leaf have been revealed to have great acaricidal effectiveness against *Psoroptes cuniculi* on rabbits (Fichi *et al.*, 2007). In an *in vitro* trial among four tested commercially available monoterpenes (Sigma–Aldrich, Milan, Italy) geraniol caused 100% mortality of *Otodectes cynotis* (dog ear mite) whereas limonene, p-cymene and *α*-pinene were proved to be less effective (Traina *et al.*, 2005).

Different experiments have shown that acaricidal and insecticidal efficacy of essential oils varies due to difference in composition of essential oil and concenteration of its active components that varies in different varieties of same plant and also part of plant (leaves, roots) (George *et al.*, 2010). For example, essential oils obtained from different varieties of *Lavandula angustifolia* showed marked differences in toxicity against *D. gallinae* (George *et al.*, 2010). Inconsistency in oil composition or fractions in different varieties and parts of plants is an inherent problem. Such differences are important because the precise composition of an essential oil may determine its acaricidal efficacy (Na *et al.*, 2011).

Furthermore, chemical composition of essential oils can also vary according to various factors such as season (for example before or after flowering), soil conditions including its type and water availability (Andrade *et al.*, 2011). Another important factor that effects the chemical composition of essential oils is genetic composition of the plant which is in accordance with plant variety. All such factors including genetic and epigenetic factors affect the biochemical synthesis of essential oils in a particular plant. So, the same species of plant with different chemical composition of essential oil may produce different biological and therapeutic effects (Sangwan *et al.*, 2001).

Effects against Flies and Fleas

Essential oils have been also effective against various flies and fleas infecting different species of animals. In *in vitro test* essential oil of *Mentha piperita* (peppermint) was found to be effective against larvae of the *Musca domestica* (house fly) (Morey and Khandagle, 2012). In another study nuisance flies such as *Stomoxys calcitrans*, *Hippobosca equina* and *Musca domestica* were declined and repelled on cattle cured with essential oils of *Mentha piperita*, *Matricaria chamomilla* and *Cinnamomum camphora* (Khater *et al.*, 2009). Repulsive properties of essential oil of *Myrica gale* were evaluated against *Culicoides impunctatus* (biting midge) and results showed that essential oil of *Myrica gale* have repulsive effects against *Culicoides impunctatus*

(Stuart & Stuart, 1998). Essential oil of *Nepeta cataria* also showed good response against *Stomoxys calcitrans* in an *in vitro* study (Zhu *et al.*, 2012).

In another study essential oils including basil, cinnamon, citronella and thymus essential oils showed larvicidal activity against *Anopheles dirus* and *Aedes aegypti* mosquito (Pitasawat *et al.*, 2007).

Various experiments have shown that essential oils play important role in controllingflies being responsible for myiasis on animals such as *Lucilia cuprina* (Callander & James, 2012) and *Synthesiomyia nudiseta* (Khalaf *et al.*, 2009). In an *in vitro* study conducted on essential oil of *Melaleuca alternifolia* (tea tree), major repulsive properties to larva of *Lucilia cuprina* have been recorded (Callander & James, 2012). Essential oils are also effective against various fleas infecting animals. It has been observed that essential oil of the *Citrus sinensis* (citrus) oil is harmful to *Ctenocephalides felis* (cat flea) (Collart & Hink, 1986). Furthermore, essential oils containing carvacrol and its derivatives caused death of flea in an *in vitro* study (Panella *et al.*, 2005).

In an experiment, insecticidal activity of essential oils from *Origanum onites*, *Satureja thymbra* and *Myrtus communis* was evaluated against different insects. Among all tested the essential oils of *Origanum onites* and *Satureja thymbra* were effective causing 100% mortality of insects (Ayvaz *et al.*, 2010).

Effects against Lice

Essential oils are also effective against various types of lice infecting animals. Various *in vitro* and *in vivo* trials have shown remarkable results against lice of veterinary importance. In an *in vitro* study, effectiveness of essential oil of *Melaleuca alternifolia* (tea tree) was evaluated against *Bovicolao cellatus* (chewing lice). The essential oils showed their antilice activity in terms of high mortality (Talbert & Wall, 2012). Different *in vitro* assays have displayed that usage of 1% quantity of tea tree caused 100% mortality of *Bovicola ovis* (sheep lice) (Callander and James, 2012). In another *in vitro* study, essential oil of *Cinnamomum camphora* (camphor) proved to be the lethal to *Haematopinus tuberculatus* and caused ovicidal action on its eggs (Khater *et al.*, 2009).

Essential oil of *Lippia multiflora* proved to have excellent potential against body lice, head lice and scabies mites, with overall efficacy exceeding as compared to synthetic drugs tested (Oladimeji *et al.*, 2000).

Mechanism of action of Essential Oils

Acaricidal and insecticidal effects of essential oils are largely associated with the presence of bioactive constituents (Boldbaatar *et al.*, 2014). Many botanical oils and their extracts are composed of more than one bioactive compound that can exert different modes of action against ectoparasites (Showler, 2017). Many studies have revealed that constituents of essential oils have harmful effect on nervous system of ectoparasites. For example, terpinen-4-ol, high in concentrations in tea tree oil, inhibits release of acetylcholinesterase which is essential for insects for their activity and synaptic transmission (Bakkalai *et al.*, 2008; Lopez & Pascual-Villalobos, 2010). Different compounds of essential oils are also known to act on Octopamine (circulating-neuromodulator) and its disruption results in complete breakdown of nervous system in insects (Hollingworth *et al.*, 1984). Furthermore, essential oils are hydrophobic in nature and cause water stress in insects by blocking the spiracles resulting in suffocation and distressing the cuticular waxes (Burgess, 2009).

Different studies have shown that essential oils components act synergistically. This may occur because some oil components aid cellular accumulation and absorption of other toxic components (Yang *et al.*, 2003; Cal, 2006). Although several hypotheses for this have been proposed, the underlying mechanism has not been fully elucidated so far. Synergistic activity observed has long been speculated to be obtained *via* complex effects in several targets due to multiple modes-of-action by different components (Tak & Isman, 2017). However, despite this complexity in their modes-of-action, the synergistic or antagonistic effects in essential oil-based insecticides seem to depend upon concentration of major constituents of particular essential oil (Tong & Coats, 2012).

Mostly essential oils are rapidly absorbed after dermal or oral administration and cross the blood-brain barrier and interact with receptors in the central nervous system. Components of essential oils are fat soluble and have the ability to permeate the membranes of the skin and act on targets organs (Adorjan & Buchbauer, 2010). Most essential oil components are metabolized and either eliminated by the kidneys in the form of polar compounds (Kohlert *et al.*, 2000). The same happens with thymol,

carvacrol, limonene and eugenol. After their oral administration, sulphate and glucuronide forms have been detected in urine and in plasma respectively (Michiels *et al.*, 2008). Due to their volatility nature and fast metabolism of its active compounds there is a minimum risk of accumulation in body tissues (Kohlert *et al.*, 2002).

Essential oils are highly complex mixtures of volatile compounds (Shibamoto, 2010), including hydrocarbons (e.g. limonene, pinene), acids (e.g. benzoic acid, geranic acid), alcohols (e.g. santalol, linalol), aldehydes (e.g. citral, cuminal), ketones (e.g. camphor), lactones (e.g. bergaptene), phenols (e.g. eugenol), phenolic ethers (e.g. anethole), oxides (e.g. 1,8 cineole) and esters (e.g. geranylacetate) (Andrade *et al.*, 2011).

Limitations of using essential oils

No doubt essential oil have wide potential uses but, their use remain limited due to toxic effects and other undesirable effects (Yang *et al*., 2005). Essential oils also deteriorate the cell membrane and cell wall structure cytoplasmic membranes and organelles of cell including mitochondria and peroxisomes (Bakkali *et al.*, 2008). Essential oils disturb the depolarization of mitochondrial membrane in cell by altering ion channels and effect ATP synthesis (Vercesi *et al.*, 1997). Essential oils such as thymol and carvacol have been proved to be to be lethal for the intestinal cells of mucosa layer due to lipophilic and hydrophobic nature (Giannenas *et al.*, 2003). Furthermore, essential oils separated from Chinese as well Egyptian plants have been reported to cause fumigant toxicity (Fu *et al.*, 2013). It should also be taken into account that essential oils and their components could cause allergic reactions and symptoms (De Groot & Schmidt, 2016).

Table No. 1
Some important essential oils reported for acaricidal and insecticidal activities

Scientific Name	Common Name	Ectoparasite	Reference
Ageratum conyzoides L	Goat weed	Ticks	Kumar *et al.,* 2016
Allium sativum L	Garlic	Mites	George *et al.*, 2010
Artemisia absinthium L	wormwood	Ticks	Jaenson *et al.*, 2005
Artemisia herba-alba Asso	Asso	Ticks	El-Seedi *et al.,* 2017
Azadirachta indica A. Juss	Neem	Ticks	Nawaz *et al.,* 2015
Brassica juncea (L) Vassili Matveievitch Czarnajew	Mustard	Mites	Kim *et al.*, 2004
Calendula officinalis L	Marigold	Ticks	El-Seedi *et al.,* 2017
Cleome hirta (Klotzsch) Oliv	Purple cleome	Ticks	Ndungu *et al.,* 1999
Syzygium aromaticum (L) Merr. & L.M.Perry	Clove	Mites	Kim *et al.*, 2004
Cleome gynandra L	Stinkweed	Ticks	Lwande *et al.,* 1999
Laurus nobilis L	Bay	Mites	Macchioni *et al.*, 2006
Lippia gracilis Schauer	Zapania Lam	Ticks	Cruz *et al.,* 2013
Melaleuca alternifolia Maiden & Betche ex Cheel	Tea tree	Mites	Magi *et al.*, 2006
Ocimum basilicum L	Sweet Basil	Ticks	Veeramani*et al.,* 2014
Origanum bilgeri P.H.Davis	Oregano	Ticks	Koc*et al.*, 2013
Pimenta dioica L	Allspice	Ticks	Martinez-Velazquez *et al.*, 2011
Tagetes minuta L	Wild marigold	Ticks	Andreotti*et al.*, 2013
Thymus vulgaris L	Thyme	Mites	George *et al.*, 2009

Table No. 2
Major constituents of some important essential oils

Scientific Name	Essential Oil	Major Constituent	Reference
Thymus vulgaris L	Thyme	Carvacrol Thymol Borneol	Fadli*et al.,* 2011
Thymus pulegioides L	Thyme	Geraniol	Miladinovic *et al.,* 2014
Origanum vulgare L	Oregano	Cymenol	Rosato*et al.,* 2010
Origanumm ajorana L	Marjoram	4-Terpineol	El-Hosseiny *et al.,* 2014
Salvia officinalis L	Sage	1,8-Cineole	El-Hosseiny *et al.,* 2014
Satureja *montana* L	Savory	Geraniol	Miladinovic *et al.,* 2014
Ocimum basilicum L	Basil	Linalool	Silva *et al.,* 2015
Aniba rosaeodora Ducke	Rosewood	Linalool	Rosato *et al.,* 2010
Melaleuca Alternifolia Maiden & Betche ex Cheel	Tea tree	Terpinen-4-ol	Rosato *et al.,* 2010
Pelargonium graveolens L'Her	Geranium	Citronellol	Rosato *et al.,* 2010
Zanthoxylum articulatum Engler	Limão-bravo	Viridiflorol Spathulenol Elemol	Rodrigues *et al.,* 2010
Allium sativum L	Garlic	Diallylle disulfide	Thomson & Ali, 2003
Mentha piperita L	Peppermint	Menthol & menthone	Sala*,* 2011
Azadirachta indica A. Juss	Neem	Hexadecanoic acid Oleic acid octadecanoic acid 4-octylphenol	Kurose &Yatagai, 2005

Concluding Remarks

On the basis of previous and recent research on essential oils against ectoparasites, it is proved that essential oils are effective in controlling ectoparasites of livestock importance. The essential oils should be considered as alternative to chemical insecticides thus delaying or averting resistance. Essential oils can act as best alternative in the treatment of ectoparasite infections. However, most of the studies reported in this review article are not so well designed and comprehensive and based on just *in vitro* trials in laboratory conditions, therefore, further extensive *in vivo*trials and experiments are needed for formulation and standardization of herbal product from these essential oilsto be used in field practices.

REFERENCES

Abbas A, Abbas RZ, Khan, JA, Iqbal Z, Bhatti MMH, Sindhu ZuD, Zia MA. 2014. Integrated strategies for the control and prevention of dengue vectors with particular reference to *Aedes aegypti*. **Pak Vet J** 34: 1 - 10.

Abbas A, Iqbal Z, Abbas RZ, Khan MK, Khan JA. 2017a. Immunomodulatory activity of *Pinus radiata* extract against coccidiosis in broiler chicken. **Pak Vet J** 37: 145 - 149.

Abbas A, Iqbal Z, Abbas RZ, Khan MK, Khan JA, Sindhu ZD, Mahmood MS, Saleemi MK, 2017b. *In vivo* anticoccidial effects of *Beta vulgaris* (sugar beet) in broiler chickens. **Microb Path** 111: 139 - 144.

Adorjan B, Buchbauer G. 2010. Biological properties of essential oils: an updated review. **Flavour Fragr J** 25: 407 - 426.

Álvarez V, Loaiza J, Bonilla R. 2008. *In vitro* control of ticks (*Boophilus microplus*; Acari: *Ixodidae*) by plant extracts. **Rev Biol Trop**

56: 291 - 302.

Andrade EHA, Alves CN, Guimarães EF, Carreira LMM, Maia JGS. 2011. Variability in essential oil composition of *Piper dilatatum* L.C. Rich. **Biochem Syst Ecol** 39: 669 - 675.

Andreotti R, Garcia MV, Cunha RC, Barros JC. 2013. Protective action of *Tagetes minuta* (Asteraceae) essential oilin the control of *Rhipicephalus microplus* (Canestrini, 1887) (Acari: Ixodidae) in a cattle pen trial. **Vet Parasitol** 197: 341 - 345.

Aslam A, Shahzad MI, Parveen S, Ashraf H, Naz N, Zehra SS, Kamran Z, Qayyum A, Mukhtar M. 2016. Evaluation of antiviral potential of different Cholistani plants against infectious bursal disease and infectious bronchitis virus. **Pak Vet J** 36: 302 - 306.

Awaad MHH, Afify MAA, Zoulfekar SA, Mohammed FF, Elmenawy MA, Hafez HM. 2016. Modulating effect of peppermint and eucalyptus essential oils on vVND infected chickens. **Pak Vet J** 36: 350 - 355.

Ayvaz A, Sagdic O, Karaborklu S, Ozturk I. 2010. Insecticidal activity of the essential oils from different plants against three stored-product insects. **J Insect Sci** 10: 1 - 13.

Bakkali F, Averbeck S, Averbeck D, Idaomar M. 2008. Biological effects of essential oils–a review. **Food ChemToxicol** 46: 446 - 475.

Beugnet F, Chauve C, Gauthey M, Beert L. 1997. Resistance of the red poultry mite to pyrethroids in France. **Vet Rec** 140: 577 - 579.

Birkett MA, Hassanali A, Hoglund S, Pettersson J, Pickett JA, 2011. Repellent activity of catmint, *Nepetacataria*, and iridoidnepeta-lactone isomers against Afro-tropical mosquitoes, ixodid ticks and red poultry mites. **Phytochemistry** 72: 109 - 114.

Boldbaatar D, El-Seedi HR, Findakly M, Jabri S, Javzan B, Choidash B, Goransson U, Hellman B. 2014. Antigenotoxic and antioxidant effects of the Mongolian medicinal plant *Leptopyrum fumarioides* (L): an *in vitro* study. **J Ethnopharmacol** 155: 599 - 606.

Burgess IF. 2009 The mode of action of dimeticone 4% lotion against head lice, Pediculuscapitis. **BMC Pharmacol** 9: 1 - 8.

Cal K. 2006. Skin penetration of terpenes from essential oils and topical vehicles. **Planta Med** 72: 311 - 316.

Callander JT, James PJ. 2012. Insecticidal and repellent effects of tea tree (*Melaleuca alternifolia*) oil against *Lucilia cuprina*. **Vet Parasitol** 184: 271 - 278.

Cetin H, Cilek JE, Oz E, Aydin L, Deveci O, Yanikoglu A. 2010. Acaricidal activity of *Satureja thymbra* L. essential oil and its major components, carvacrol and gamma-terpinene against adult *Hyalomma marginatum* (Acari: Ixodidae). **Vet Parasitol** 170: 287 - 290.

Cetin H, Cilek JE, Aydin L, Yanikoglu A. 2009. Acaricidal effects of the essential oil of *Origanum minutiflorum* (Lamiaceae) against *Rhipicephalus turanicus* (Acari: Ixodidae). **Vet Parasitol** 160: 359 - 361.

Chen Z, Liu, Q, Liu, JQ, Xu, BL, Lv, S, Xia S, Zhou, XN. 2014. Tick-borne pathogens and associated co-infections in ticks collected from domestic animals in central China. **Parasit Vectors** 7: 1 - 8.

Chen L, Jiang T, Li X, Wang Q, Wang Y, Li Y, 2016. Immunomodulatory activity of β-glucan and mannan-oligosaccharides from *Saccharomyces cerevisiae* on broiler chickens challenged with feed-borne *Aspergillus fumigatus*. **Pak Vet J** 36: 297 - 301.

Collart MG, Hink WF. 1986 Sublethal effects of D-limonene on the cat flea, *Ctenocephalides felis*. **Entomol Exp Appl** 42: 225 - 229.

Cruz EM, Costa-Junior LM, Pinto JA, SantosDA, Araujo, SA, Arrigoni-Blank MF, Bacci L, Alves PB, Cavalcanti SC, Blank AF, 2013. Acaricidal activity of *Lippia gracilis* essential oil and its major constituents on the tick *Rhipicephalus* (Boophilus) *microplus*. **Vet Parasitol** 195: 198 - 202.

De Groot AC, Schmidt E. 2016. **Essential oils: contact allergy and chemical composition;** CRC Press: Boca Raton, FL, USA.

Demessie Y, Derso S. 2015. Tick borne hemoparasitic diseases of ruminants: A Review. **Adv Biol Res** 9: 210 - 224.

El-Hosseiny L, El-Shenawy M, Haroun M, Abdullah F. 2014. Comparative evaluation of the inhibition effect of some essential oils with antibiotics against *Pseudomonas aeruginosa*. **Int J Antibiot** 2014: 1 - 15.

Ellse L, Burden F, Wall R. 2013. Control of the

chewing louse *Bovicola* (*Werneckiella*) ocellatus in donkeys, using essential oils. **Med Vet Entomol** 27: 408 - 413.

Ellse L, Burden F, Wall R. 2012. Pyrethroid tolerance in the chewing louse *Bovicola* (*Werneckiella*) *ocellatus*. **Vet Parasitol** 188: 134 - 139.

Ellse L, Wall R. 2014. The use of essential oils in veterinary ectoparasite control: a review. **Med Vet Entomol** 28: 233-243.

El-Seedi HR, Azeem M, Khalil NS, Sakr HH, Shaden A, Khalifa M, Awang K, Saeed A, Mohamed A. Farag MA, Al Ajmi MF, Palsson K, Borg-Karlson A. 2017. Essential oils of aromatic Egyptian plants repel nymphs of the tick *Ixodes ricinus* (Acari: Ixodidae). **Exp Appl Acarol** 73: 139 - 157.

Esmacily M, Bandani A, Zibaee I, Sharijian J, Zare S. 2017. Sublethal effects of Artemisia annua L and Rosmatinus officinalis L, essential oils on life table parameters of Tetranychus urticae (Acari: tetranychidae). **Persian J Acarology** 6:

Fadli M, Chevalier J, Saad A, Mezrioui NE, Hassani L, Pagès JM. 2011. Essential oils from Moroccan plants as potential chemosensitisers restoring antibiotic activity in resistant Gram-negative bacteria. **Int J Antimicrob Agents** 38: 325 - 330.

Fang F, Candy K, Melloul E, Bernigaud C, Chai L, Darmon C, Durand R, Botterel F, Chosidow O, Izri A, Huang W, Guillot J. 2016. *In vitro* activity of ten essential oils against *Sarcoptes scabiei*. **Parasit Vectors** 9: 1 - 8.

Fichi G, Flamini G, Zaralli LJ, Perrucci S. 2007. Efficacy of an essential oil of *Cinnamomum zeylanicum* against *Psoroptes cuniculi*. **Phytomedicine** 14: 227 - 231.

Foil LD, Coleman P, Fragoso-Sanchez HE, Garcia-Vazquez Z, Guerrero FD, Jonsson NN, Langstaff IG, Li AY, Machila N, Miller RJ, Morton J, Pruett JH, Torr S. 2004. Factors that influence the prevalence of acaricide resistance and tick-borne diseases. **Vet Parasitol** 125: 163 - 181.

Fu C, Wan T, Jiang Z, Wu H, Feng J, Ma Z, Zhang X. 2013. Fumigation activity of esssential oils against *Culex pipen*s pallens (*Diptera: Culicidae*). **Acta Entomol Sin** 56: 779 - 785.

Garcia MV, Matias J, Barros JC, Lima DP, Lopes RS, Andreotti R. 2012. Chemical identification of *Tagetes minuta* Linnaeus (*Asteraceae*) essential oil and its acaricidal effect on ticks. **Rev Bras Parasitol Vet** 21: 405 - 411.

George DR, Callaghan K, Guy JH, Sparagano OAE. 2008. Lack of prolonged activity of lavender essential oils as acaricides against the poultry red mite (*Dermanyssus gallinae*) under laboratory conditions. **Res Vet Sci** 85: 540 - 542.

George DR, Sparagano OAE, Port G, Okello E, Shiel RS, Guy JH. 2009. Repellence of plant essential oils to *Dermanyssus gallinae* and toxicity to the non-target invertebrate *Tenebrio molitor*. **Vet Parasitol** 162: 129 - 134.

George DR, Sparaganon OAE, Port G, Okello E, Shiel RS, Guy JH. 2010. Environmental interactions with the toxicity of plant essential oils to the poultry red mite *Dermanyssus gallinae*. **Med Vet Entomol** 24: 1 - 8.

Giannenas I, Florou-Paneri P, Papazahariadou M, Christaki E, Botsoglou NA, Spais AB. 2003. Effect of dietary supplementation with oregano essential oil on performance of broilers after experimental infection with *Eimeria tenella*. **Arch Tierernahr** 57: 99 - 106.

Habeeb SM. 2010. Ethno-veterinary and medical knowledge of crude plant extracts and its methods of application (traditional and modern) for tick control. **World Appl Sci J** 11: 1047 - 1054.

Hollingworth RM, Johnstone EM, Wright N. 1984. In: Magee PS, Kohn GK, Menn JJ (eds), **Pesticide synthesis through rational approaches**. ACS Symposium Series No. 255, American Chemical Society, Washington DC, USA.

Ibrahim MA, Kainulainen P, Aflatuni A, Tiilikkala K, Holopainen JK. 2001. Insecticidal, repellent, antimicrobial activity and phytotoxicity of eseential oils: with special reference to limonene and its suitability for control of insect pests. **Agric Food Sci Finland** 10: 243 - 259.

Idris M, Abbas RZ, Masood S, Rehman T, Farooq U, Babar W, Hussain R, Raza A, Riaz U. 2017. The potential of antioxidant rich essential oils against avian coccidiosis. **World's Poult Sci J** 73: 89 - 104.

Ijaz A, Javed I, Aslam B, Khan JA, Khaliq T, Rahman ZU, Khan MZ, Iqbal Z, Naeem MA, Ashraf MM, 2016. Nephroprotective and antioxidant effects of *Moringa oleifera* (Sohanjna) in paracetamol induced nephrotoxic albino rabbits. **Pak Vet J** 36: 292 - 296.

Iori A, Grazioli D, Gentile E, Marano G, Salvatore G. 2005. Acaricidal properties of the essential oil of *Melaleuca alternifolia*Cheel (tea tree oil) against nymphs of *Ixodes ricinus.***Vet Parasitol** 129: 173-176.

Jabbar A, Abbas T, Sindhu ZU, Saddiqi HA, Qamar MF, Gasser RB. 2015. Tick-borne diseases of bovines in Pakistan: Major scope for future research and improved control. **Parasit Vectors** 8: 1 - 13.

Jaenson TGT, Palsson K, Borg-Karlson AK. 2005. Evaluation of extracts and oils of tick-repellent plants from Sweden. **Med Vet Entomol** 19: 345 - 352.

James PJ, Callander JT. 2012. Bioactivity of tea tree oil from *Melaleuca alternifolia* against sheep lice (*Bovico laovis* Schrank) *in vitro*. **Vet Parasitol** 187: 498 - 504.

Khalaf AFA, Hussein KT, Shoukry KK. 2009. Biocidal activity of two botanical volatile oils against the larvae of *Synthesiomyia nudiseta* (Wulp) (Diptera: *Muscidae*). **Egypt Acad J Biol Sci** 2: 89 - 101.

Khaliq T, Mumtaz F, Rahman ZU, Javed I, Iftikhar A. 2015. Nephroprotective potential of *Rosa damascena* mill flowers, *Cichorium intybus* Linn roots and their mixtures on gentamicin-induced toxicity in albino rabbits. **Pak Vet J** 35: 43 - 47.

Khan MN, Sajid MS, Rizwan HM, Qudoos A, Abbas RZ, Riaz M, Khan MK, 2017. Comparative efficacy of six anthelmintic treatments against natural infection of fasciola species in sheep. **Pak Vet J** 37: 65 - 68.

Khater HF, Ramadan MY, El-Madawy RS. 2009. Lousicidal, ovicidal and repellent efficacy of some essential oils against lice and flies infesting water buffaloes in Egypt. **Vet Parasitol** 164: 257 - 266.

Kim SI, Yi JH, Tak J, Ahn YJ. 2004. Acaricidal activity of plant essential oils against *Dermanyssus gallinae (Acari: Dermanyssidae)*. **Vet Parasitol** 120: 297 - 304.

Kim SI, Na YE, Yi JH, Kim BS, Ahn YJ. 2007. Contact and fumigant toxicity of oriental medicinal plant extracts against *Dermanyssus gallinae* (*Acari: Dermanyssidae*). **Vet Parasitol** 145: 377 - 382.

Koc S, Oz E, Cinbilgel I, Aydin L, Cetin H. 2013. Acaricidal activity of *Origanum bilgeri* P.H. Davis (Lamiaceae) essential oil and its major component, carvacrol, against adult *Rhipicephalus turanicus* (Acari: Ixodidae). **Vet Parasitol** 193: 316 - 319.

Kohlert C, Schindler G, Marz RW, Abel G, Brinkhaus B, Derendorf H; Grafe EU, Veit M. 2002. Systemic availability and pharmacokinetics of thymol in humans. **J Clin Pharmacol** 42: 731 - 737.

Kohlert C, van Rensen I, Marz R, Schindler G, Graefe EU, Veit M. 2000. Bioavailability and pharmacokinetics of natural volatile terpenes in animals and humans. **Planta Medica** 66: 495 - 505.

Kumar, KG, Tayade, AB, Kumar, R, Gupta S, Sharma AK, Nagar G, Tewari SS, Kumar B, Rawat AK, Srivastava S, Kumar S, Ghosh S. 2016. Chemo-profiling and bioassay of phytoextracts from *Ageratum conyzoides* for acaricidal properties against *Rhipicephalus* (*Boophilus*) *microplus* (Acari: Ixodidae) infesting cattle and buffaloes in India. **Ticks Tick Borne Dis** 7: 342 - 349.

Kurose K, Yatagai M. Components of the essential oils of *Azadirachta indica* A. Juss, *Azadirachta siamensis* Velton, and *Azadirachta excels* (Jack) Jacobs and their comparison. **J Wood Sci** 2: 185 - 188.

Liaqat I, Pervaiz Q, Bukhsh, SJ, Ahmed SI, Jahan N. 2016. Investigation of bactericidal effects of medicinal plant extracts on clinical isolates and monitoring their biofilm forming potential. **Pak Vet J** 36: 159 - 164.

Lopez MD, Pascual-Villalobos MJ. 2010. Mode of inhibition of acetylcholinesterase by monoterpenoids and implications for pest control. **Ind Crops Prod** 31: 284 - 288.

Lwande W, Ndakala AJ, Hassanali A, Moreka L, Nyandat E, Ndungu M, Amiani H, P.M. Gitu PM, Malonza MM, Punyua DK. 1999. *Gynandropsis gynandra* essential oil and its constituents as tick (*Rhipicephalus appendiculatus*) repellents. **Phytochemistry** 50: 401 - 405.

Macchioni F, Perrucci S, Cioni P, Morelli L, Castilho P, Cecchi F. 2006. Composition and acaricidal activity of *Laurus novocanariensis* and *Laurus nobilis* essential oils against Psoroptescuniculi .**J Essent Oil Res** 18: 111 - 114.

Magi E, Jarvis T, Miller I. 2006. Effects of different plant products against pig mange mites. **Acta Vet Brno** 75: 283 - 287.

Martinez-Velazquez M, Castillo-Herrera GA, Rosario-Cruz R, Flores-Fernandez JM, Lopez-Ramirez J, Hernandez-Gutierrez R, Lugo-Cervantes ED. 2011. Acaricidal effect and chemical composition of essential oils extracted from *Cuminum cyminum*, *Pimenta dioica* and *Ocimum basilicum* against the cattle tick *Rhipicephalus* (*Boophilus*) *microplus* (Acari: Ixodidae). **Parasitol Res** 108: 481 - 487.

Masood S, Abbas RZ, Iqbal Z, Mansoor MK, Sindhu ZD, Zia MA, Khan JA. 2013. Role of natural antioxidants for the control of coccidiosis in poultry. **Pak Vet J** 33: 401 - 407.

Maxwell CA, Msuya E, Sudi M, Njunwa KJ, Carneiro IA, Curtis CF. 2002. Effect of community-wide use of insecticide-treated nets for 3-4 years on malarial morbidity in Tanzania. **Trop Med Int Health** 7: 1003 - 1008.

Michiels J, Missotten J, Dierick N, Fremaut D, Maene P, De Smet S. 2008. *In vitro* degradation and *in vivo* passage kinetics of carvacrol, thymol, eugenol and transcinnnamaldehyde along the gastrointestinal tract of piglets. **J Sci Food Agric** 88: 2371 - 2381.

Miladinovic DL, Ilic BS, Kocic BD, Miladinovic MD. 2014. An *in vitro* antibacterial study of savory essential oil and geraniol in combination with standard antimicrobials. **Nat Prod Commun** 9: 1629 - 1632.

Morey RA, Khandagle, AJ. 2012. Bioefficacy of essential oils of medicinal plants against housefly, *Muscadomestica* L. **Parasitol Res** 111: 1799 - 1805

Na YE, Kim SI, Bang HS, Kim BS, Ahn YJ. 2011. Fumigant toxicity of cassia and cinnamon oils and cinnamaldehyde and structurally related compounds to *Dermanyssus gallinae* (Acari: Dermanyssidae). **Vet Parasitol** 178: 324 - 329.

Nawaz M, Sajid SM, Zulfiqar A, Muhammad W, Tanveer A, Abid H, Abrar M, S. Asim S, Muhammad Z, Imran K. 2015. Anti-Tick Activity of leaves of *Azadirachta indica*, *Dalbergia sisso* and *Morus alba* against *Rhipicephalus microplus*. **Acta Parasitol Globalis** 6: 60 - 64.

Ndungu MW, Chhabra SC, Wande WL. 1999. *Cleome hirta* essential oil as livestock tick (*Rhipicephalus appendiculatus*) and maize weevil (*Sitophilus zeamais*) repellent. **Fitoterapia** 70: 514 - 516.

Ntalli NG, Ferrari F, Giannakou I, Menkissoglu-Spiroudi U. 2010. Phytochemistry and nematicidal activity of the essential oils from 8 Greek lamiaceae aromatic plants and 13 terpene components. **J Agric Food Chem** 58: 7856 - 7863.

Niroumand MC, Farzaei MH, Karimpour-Razkenari EE, Amin G, Khamnavi M, Akbarzadeh T, Shams-Ardekani MR. 2016. An evidence-based review on medicinal plants used as insecticide and insect repellent in traditional Iranian medicine. **Iran Rad Crescent Med** 18: e22361.

Oladimeji FA, Orafidiya OO, Ogunniyi TA, Adewunmi TA. 2000. Pediculocidal and scabicidal properties of *Lippia multiflora* essential oil. **J Ethnopharmacol** 72: 305 - 311.

Olivares-Pérez J, Rojas-Hernández S, Valencia-Almazan MT, Gutiérrez-Segura I, Míreles-Martínez EJ. 2011. Prevalence of resistant strains of *Rhipicephalus microplus* to acaricides in cattle ranch in the tropical region of Tecpan of galeana, Guerrero Mexico. **Pak Vet J** 31: 366 - 368.

Opara MN, Santali A, Mohammed BR, Jegede OC. 2016. Prevalence of haemoparasites of small ruminants in Lafia Nassarawa State: A Guinea Savannah Zone of Nigeria. **J Vet Adv** 6: 1251 - 1257.

Pamo ET, Tendonkeng F, Kana JR, Khan PV, Boukila B, Lemoufouet J, Miegoue E, Nanda AS. 2005. A study of the acaricidal properties of an essential oil extracted from the leaves of *Ageratum houstonianum*. **Vet Parasitol** 128: 319 - 323.

Panella NA, Dolan MC, Karchesy JJ, Xiong Y, Peralta-Cruz J, Khasawneh M, Montenieri JA, Maupin GO. 2005. Use of novel

compounds for pest control: insecticidal and acaricidal activity of essential oil components from heartwood of Alaska yellow cedar. **J Med Entomol** 42: 352 - 358.

Perrucci S, Macchioni G, Cioni PC, Flamini G, Morelli I, Taccini F. 1996. The activity of volatile compounds from *Lavandula angustifolia* against *Psoraptes cuniculi*. **Phytotherapy Res** 10: 5 - 8.

Pitasawat B, Champakaew D, Choochote W, Jitpakdi A, Chaithong U, Kanjanapothi D, Rattanachanpichai E, Tippawangkosol P, Riyong D, Tuetun B, Chaiyasit D. 2007. Aromatic plant-derived essential oil: an alternative larvicide for mosquito control. **Fitoterapia** 78: 205 - 210.

Qureshi AS, Rehan S, Enbergs H. 2017. *Nigella sativa* seed extract affects granulocyte phagocytosis and lymphocytes proliferation in goats. **Pak Vet J** 37: 411 - 414.

Radsetoulalova I, Hubert J, Lichovnikova M. 2017. Acaricidal activity of plant essential oils against poultry red mite (Dermanyssus gallinae). **Mendel Net** 24: 260 - 265.

Rehman N, Jahan N, Rahman KU, Khan KM, Zafar F, 2016. Anti-arrhythmic potential of *Coriandrum sativum* seeds in salt induced arrhythmic rats. **Pak Vet J** 36: 465 - 471.

Ribeiro VLS, Toigo E, Bordignon SAL, Goncalves K, von Poser G. 2007. Properties of extracts from the aerial parts of *Hypericum polyanthemum* on the cattle tick *Boophilus microplus*. **Vet Parasitol** 147: 199 - 203.

Ribeiro VLS, Avancini C, Goncalves K, Toigo E, von Poser G. 2008. Acaricidal activity of *Calea serrata* (*Asteraceae*) on *Boophilus microplus* and *Rhipicephalus sanguineus*. **Vet Parasitol** 151: 351 - 354.

Rodrigues FF, Costa JG, Coutinho HD. 2010. Enhancement of the antibiotic activity of gentamicin by volatile compounds of *Zanthoxylum articulatum*. **Indian J Med Res** 131: 833 - 835.

Rosato A, Piarulli M, Corbo F, Muraglia M, Carone A, Vitali ME, Vitali C. 2010. *In vitro* synergistic antibacterial action of certain combinations of gentamicin and essential oils. **Curr Med Chem** 17: 3289 - 3295.

Sala H. 2011. Aromatherapy: current and emerging applications. **Altern Complement Ther** 17: 26 - 31.

Sands B, Ellse L, Wall R. 2016. Residual and ovocidal efficacy of essential oil-based formulations *in vitro* against the donkey chewing louse *Bovicola ocellatus*. **Med Vet Entomol** 30: 78 – 84.

Sangwan NS, Farooqi AHA, Shabih F, Sangwan RS. 2001. Regulation of essential oil production in plants. **J Plant Growth Regul** 34: 3 - 21.

Sharifi-Rad J, Sureda A, Tenore GC, Daglia M, Sharifi-Rad M, Valussi M, Tundis R, Sharifi-Rad M, Loizzo MR, Ademiluyi AO, Sharifi-Rad R, Ayatollahi A, Iriti M. 2017. Biological activities of essential oils: from plants chemoecology to traditional healing systems. **Molecules** 22: 70

Shibamoto K, Mochizuki M, Kusuhara M. 2010. Aroma therapy in anti-aging medicine. **J Anti Aging Med** 7: 55 - 59.

Showler AT. 2017. Botanically based repellent and insecticidal effects against horn flies and stable flies (*Diptera: Muscidae*). **J Integr Pest Manag** 8: 1 - 11.

Silva AV, da Sousa PJ, Pessôa LFH, de Freitas FRA, Coutinho DMH, Alves BNL, Lima OE. 2015. *Ocimum basilicum*: Antibacterial activity and association study with antibiotics against bacteria of clinical importance. **Pharm Biol** 54: 863 - 867.

Stuart AE, Stuart CLE. 1998. A microscope slide test for the evaluation of insect repellents as used with *Culicoides impunctatus*. **Entomol Exp Appl** 89: 277 - 280.

Tak JH, Isman MB. 2017. Penetration-enhancement underlies synergy of plant essential oil terpenoids as insecticides in the cabbage looper, *Trichoplusia ni*. **Sci Rep** 7: 1 - 11.

Talbert R, Wall R. 2012. Toxicity of essential and non-essential oils against the chewing louse, *Bovicola* (Werneckiella) *ocellatus*. **Res Vet Sci** 93: 831 - 835.

Thomson M, Ali M. 2003. Garlic [*Allium sativum*]: a review of its potential use as an anti-cancer agent. **Current Cancer Drug Targets** 3: 67 - 81.

Tong F, Coats JR. 2012. Quantitative structure-activity relationships of monoterpenoid binding activities to the housefly GABA receptor. **Pest Manag Sci** 68: 1122 -1129.

Traina O, Cafarchia C, Capelli G, Iacobellis NS, Otranto D. 2005. *In vitro* acaricidal activity of four monoterpenes and solvents against

Otodectes cynotis (Acari: Psoroptidae). **Exp Applied Acarol** 37: 141 - 146.

Veeramani V, Sakthivelkumar S, Tamilarasan K, Aisha SO, Janarthanan S. 2014. Acaricidal activity of *Ocimum basilicum* and *Spilanthes acmella* against the ectoparasitic tick, *Rhipicephalus* (*Boophilus*) *microplus (Arachinida: Ixodidae).* **Trop Biomed** 31: 414 - 421.

Vercesi AE, Kowaltowski AJ, Grijalba MT, Meinicke AR, Castilho RF. 1997. The role of reactive oxygen species in mitochondrial permeability transition. **Biosci Rep** 17: 43 - 52.

Yadav PK, Rafiqi SM, Panigrahi PN, Kumar D, Kumar R, Kumar S. 2017. Recent trends in control of ectoparasites: A review. **J Entomol Zool Stud** 5: 808 - 813.

Yang P, Ma Y, Zheng S. 2005. Adulticidal activity of five essential oils against *Culex pipiens quinquefasciatus*. **J Pest Sci** 30: 84 - 89.

Yang YC, Lee SH, Lee WJ, Choi DH, Ahn YJ. 2003. Ovicidal and adulticidal effects of *Eugenia caryophyllata* bud and leaf oil compounds on *Pediculus capitis.* **J Agric Food Chem** 51: 4884 - 4888.

Zahid MU, Hussain MH, Saqib M, Neubauer H, Abbas G, Khan I, Mansoor MK, Asi MN, Ahmad T, Muhammad G. 2016. Sero prevalence of Q fever (*Coxiellosis*) in small ruminants of two districts in Punjab, Pakistan. **Vect Borne Zoonotic Dis**16: 449 - 454.

Zaman MA, Rehman TU, Abbas RZ, Babar W, Khan MN, Riaz MT, Hussain R, Ghauri T, Arif M, 2017a. Therapeutic potential of Ivermectin, doramectin and trichlorophan against *Psoroptes ovis* in sheep and cattle of Cholistan. **Pak Vet J** 37: 233 - 235.

Zaman MA, Iqbal Z, Sindhu ZUD, Abbas RZ, Qamar MF, 2017b. An overview of plants with acaricidal and anthelmintic properties. **Int J Agric Biol** 19: 957 - 968.

Zhu JJ, Berkebile DR, Dunlap CA, Zhang A, Boxler D, Tangtrakulwanich K, Behle RW, Baxendale F, Brewer G. 2012. Nepetalactones from essential oil of *Nepeta cataria* represent a stable fly feeding and oviposition repellent. **Med Vet Entomol** 26: 131 - 138.