

Research/Technical Note

Advanced Demiter Technique for Effective Red Mite Control in Poultry a Study

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Abstract

The Red Mite, *Dermanyssus gallinae*, the one ectoparasite affecting the poultry industry globally, especially in the layer production causing immense economic losses and culture failures. This pest is seen to be viable for more than 6 months even in the empty sheds and cages, its different life history stages, causing different problems, making its control or eradication a next to impossible task. The most prevalent methods of control are synthetic pesticides, synthetic acaricides, sticky tapes and dust baths. The sticky tapes and dust baths are uneconomical, while the Chemical control of poultry red mites happens to be the most dominant, but the mites seems to have developed resistance to these acaricides and their toxicity affecting the nontarget organisms and the environment too. Hence there seems to be an increasing interest in the control and eradication of the Red Mites with the proposal of alternative control methods. The best alternative method being the use of the natural acaricides, the use of plant substances like essential oils with an add on of inert dusting powders, that have the capability of either repelling or causing death to the Red Mite. The all new Demiter technique delves into the understanding of the working of the phytochemical components, the essential oils and the inert dusting powder, that work three dimensionally, the mite develops gustatory avoidance, olfactory repellency and contact toxicity, both internal and external. This technique being safe, has proved efficacy without the development of resistance. Being economical, target specific alternative for the control of mite infestations, as rich sources of bioactive phytochemicals that have various efficacies such as ovicidal, repellent, anti-feeding activities that provide fast assured and potent acaricidal efficacy with proven safety.

Keywords

Acaricide, Dusting Powder, Ectoparasite, Essential Oil, Ovicidal, Poultry Red Mite, Repellent

1. Introduction

Dermanyssus gallinae official Latin name for the red mite means the “hen skin-biter” a blood feeding mite that usually attacks its host at night lurking and reproducing in the cracks and crevices during the day.

This is the most harmful ectoparasite of poultry causing itching dermatitis, by sucking blood it causes blood deficiency leading to anaemia, restlessness and irritation leading

to stress, blood-stained eggs in layers and even death in high infestations. Due to its haemophagous nature requires blood meal for its metamorphosis especially the last 3 stages to complete its life cycle and also during oviposition for egg development.

This mite is considered a vector [4] for many pathogens like *Erysipelothrix rhusiopathiae*, *Escherichia coli*, *Strepto-*

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myces sp., Staphylococcus sp., Yersinia, Listeria, Pasteurella sp. and Rickettsia sp.), Newcastle disease, fowl typhoid, fowl cholera etc.

This infection makes the birds suffer from skin irritation with lesions on the breast and legs, feather plucking, pale comb and wattle with anemia being the visible conditions, the birds also suffer from loss of plumage, weight and energy. The egg laying is reduced. All these due to mite infestation, put together or individually, death of the bird and lead to production loss.

An immediate need urges for the substitution of the mite control chemicals through the adoption of safer alternative control strategies like the Phytotherapeutics, the phytochemical plant derivatives with acaricidal activity, with specific action against the red mite and harmless to the other non target group of organisms and the environment.

These plant extracts as essential oils control the mite infestation, reduce the relapsation frequency and also enhance the growth and health of the bird. Thereby stabilizing the overall production too.

Red Mite's Story

The Red Mite, *Dermanyssus gallinae* a haematophagous ectoparasite that lives and feeds on exterior of the host typically at night. It does not stay on the bird at all times and rarely feeds during the day. These are small, usually darker after a blood meal, these can be seen with the naked eye. They lay

eggs that appear translucent.

Once laid the eggs take about five days for their first blood meal as protonymphs. When they reach the adult stage, at about 10 days old, they start to feed more often. These are typically nocturnal, stay hidden during the day in cracks and crevices, cribs, roosts etc., and appear as clusters.

The Red Mite has an indirect life cycle [2] involving four stages – the egg, the larva, protonymph, deutonymph and adult. In 2-3 days the six legged non feeding Larvae hatch out of the eggs. The first moult in 2 days leads to the first nymphal stage the eight legged feeding Protonymph, the subsequent moult in 1 or 2 days leads to the second nymphal stage the eight legged feeding Deutonymph, the further moults in 2 or 3 days develop into the adults that are eight legged and feeding stage. Out of the 4 life history stages the eggs non feeding, the adult males feed only occasionally, while the protonymph, deutonymph and adult females feed regularly on the host blood. After feeding a female red mite will mate and within 1-2 days lays the eggs. A blood meal takes 1 to 2 hours usually at night when birds are roosting.

This mite can transform from egg to adult within a week. This high reproductive rate is the reason of concern in poultry and top up to this, the deutonymph and adult are capable of resisting dessication and can live on without feeding for more than 6 months.

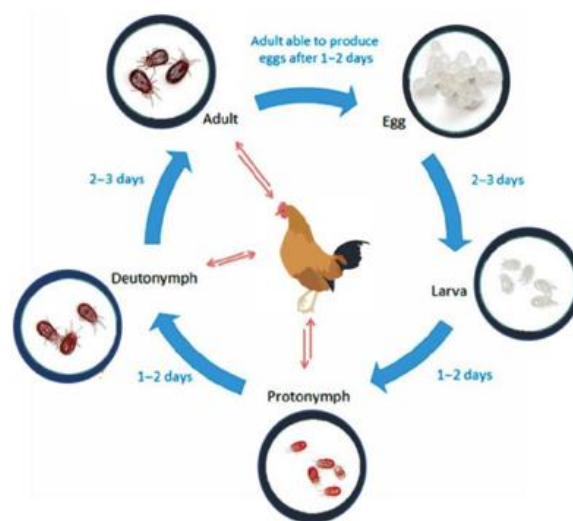


Figure 1. Microscopic image of Red Mite & Diagrammatic representation of Red Mite's life cycle stages.

The Mite or Acari's exoskeleton is chitinous, which is tough, the proteins and hormones together make it a sclerotized layer with an outer waxy exoskeleton, known as the epicuticle, which prevents loss of water and avoids dessication.

All these adaptations of the Red Mite make the infestation control more difficult. [8]

The eggs are laid in the crevices of the coop, roof and floor of the house. Red mites nest in dark places where the chickens can't eat them. [3]



Figure 2. Red Mite's housing activity in the Poultry shed.

2. Red Mite's Impact on Poultry

Dermanyssus gallinae is responsible for the direct and indirect damage to the bird and the poultry house. Even the removal of the bird from the house does not help in eliminating the mites since their viability in the empty houses is more than 8 months. So as and when the new batch of birds are added to the house, the mites reinfest.

Hens under infestation suffer restlessness, agitation, sleep deprivation, increased preening and feather pecking, the chronic distress making them more susceptible to diseases. [6]

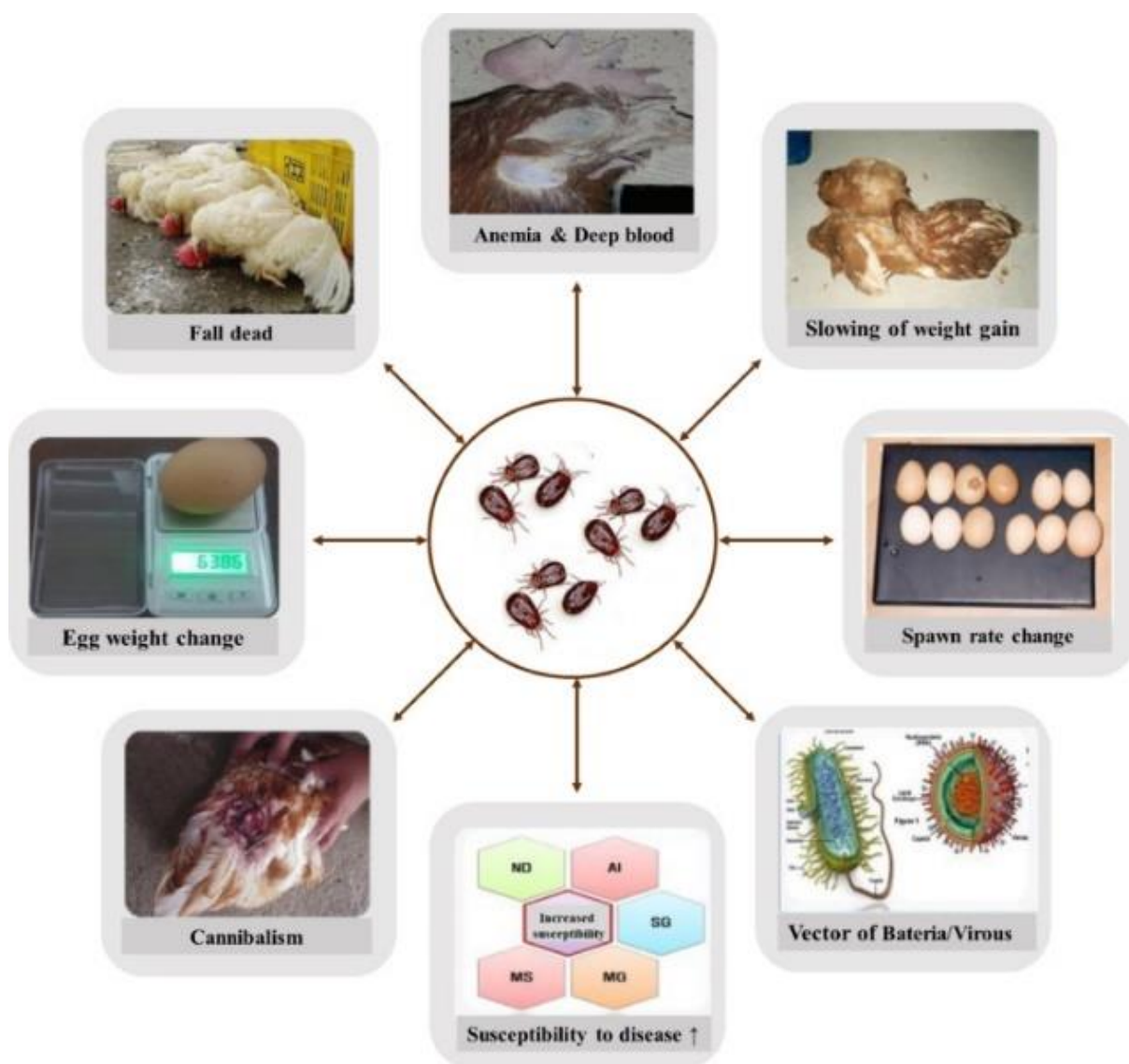


Figure 3. Effects of Red Mite infection in Poultry.

2.1. Combating Red Mite

Many ways are in vogue for the control of Mite infestation in Poultry, since the economic loss incurred is large. Many areas and avenues have been worked out of which using synthetic acaricides takes the first place. Poultry infested with Red Mite are typically treated with synthetic acaricides [1] to reduce or eliminate the mite, many of these have been restricted, while the Red mites have developed resistance to these, making their control and management more challenging. Hence coming up with the non resistant, non toxic biological control the Plant based phytochemicals being the best of all options.

Plant-Derived Compounds with acaricidal and toxic activity as well as repellent or attractive effects have promising potential as alternative nonchemical methods against Poultry

Red Mite.

These plant derived compounds either disrupt the formation of the building blocks of invertebrate exoskeletons (chitin), or interfere with maturation by mimicking or inhibiting juvenile hormone leading to delayed or premature development of the pupae or adults. Their volatile components exhibit a neurotoxic effect rather than just a mechanical pathway effect.

The naturally available plant extracts, are good sources of natural substances that are eco-friendly and sustainable. They are readily available, biodegradable, and have high volatility, low-ecological toxicity and low-environmental residual activity, with a huge development potential in controlling mites mainly focuses on their acaricidal activity. Control of infestation can be achieved by spraying or dusting the birds and the house with these natural phyto bio - controllers.



Figure 4. Appearance of Red Mite on and around the Poultry bird.

2.2. Significance of Natural Organic Phyto Deterrents of Red Mite

Acaricidal Activity of Plant Extracts

The growing interest and need to find alternative and natural acaricides has led to the plants and their derivatives. These secondary metabolites of plants [12] due to their toxic, repellent, attractant and growth regulator properties, have been greatly sought and widely investigated for their potential in Red Mite control.

Alkaloid Compounds

Alkaloids are important nitrogen-containing natural organic compounds. The modification at the $C=N^+$ double bond in alkaloids like sanguinarine and chelerythrine determined the acaricidal properties of the derivatives, and alkaloids showed promise for the development of new isoquinoline acaricidal agents.

The action mechanism of these natural products is they modify the mites' enzymes that are involved in the nervous and energy metabolism.

Terpenoids

Thymol, Eugenol, Carvacrol [13], Geraniol and other Monoterpenes [11] found in many natural essential oils possess strong toxicity against mites.

The mechanism of acaricidal activity involves interference

with the energy metabolism and nerve conduction of the mites. 1, 8-Cineole, a monoterpene can change the activity of superoxide dismutase, nitric oxide synthase and GSTs in the nervous system. Also exhibited promising miticidal activity resulting in residue-free eggs, indicating its potential in environmentally friendly pest management practices.

Phenylpropanoids

Cinnamic acid & Cinnamaldehyde show acaricidal activity due to their α , β -unsaturated aldehydes, that also are noted for their remarkable antimicrobial properties.

Mechanism of action [7, 10] involves several signaling pathways, including PPAR (peroxisome proliferator-activated receptor), NF-kappa B, TNF (tumor necrosis factor), Rap1, and Ras pathways.

The Demeter essential oils play a significant role in mite killing, by inhibiting the mitochondrial respiratory chain in the oxidative phosphorylation pathway by binding to NADH dehydrogenase chain 2 resulting in the death of mite, apart from excellent acaricidal activity also showed ovicidal, larvicidal and adulticidal activity, affecting the reproductivity of adults.

Natural Inorganic Materials

The Mite's chitinous exoskeleton is made up of a protective lipid layer that acts as a water barrier. The inert dusting powder damages it by abrasion, absorption, release of altered adhesive properties and physical disruption, leading to desiccation.

water loss, dehydration, dessication and finally death.

2.3. Unique Demiter Technique and Working

Neem Oil, Peppermint Oil, Rosemary Oil and Cinnamom oil with an added natural dusting powder, a unique combo. This synergistic blend of essential oils and the dusting powder together showed remarkable acaricidal effects, like ovicidal and adulticidal properties, also showed a repellency action against the adult red mites, by depressing their feeding and movement mainly. Earlier studies on these essential oils prove and show that.

Neem oil studies report its toxicity towards the Poultry Red Mite, it has a broad range of terpenoids, polyacetylenes, sugars, flavonoids and alkaloids, acting as acaricides, antifeedants and repellents. Suppresses the nervous system by suppressing acetylcholine esterase activity and also other targets like octopamine receptors, tyramine receptors, sodium and gated chloride channels.

Essential oils peppermint and menthol, have time tested records for their acaricidal activity against Red mite, while menthol showed the highest activity, by contact and repulsion

Rosemary essential oil showed acaricidal and repellent ac-

tivity against the Red Mite. On contact, the mite's epidermis started to shrink. The enzyme level of catalase, acetylcholinesterase and superoxide dismutase seem to have decreased significantly, there seemed to be was a significant increase in nitric oxide synthase and glutathione-s-transferases activities in Red Mite.

Cinnamom oils predominant component was cinnamaldehyde which is lethal for larvae and nymphs. The essential oil, (*E*)-cinnamaldehyde exhibited acaricidal activity. This also induced physical stigmata and prevented the normal breathing of mites and repellent activity.

3. An Insight into the Demiter Technique's Mode of Action and Effectiveness

The essential oils of Demiter Technique act on acetylcholine receptors by competitive inhibition, stop its binding, resulting in depolarization, increased chloride ion flow, hyperstimulated muscle cell resulting in paralysis and mite death.

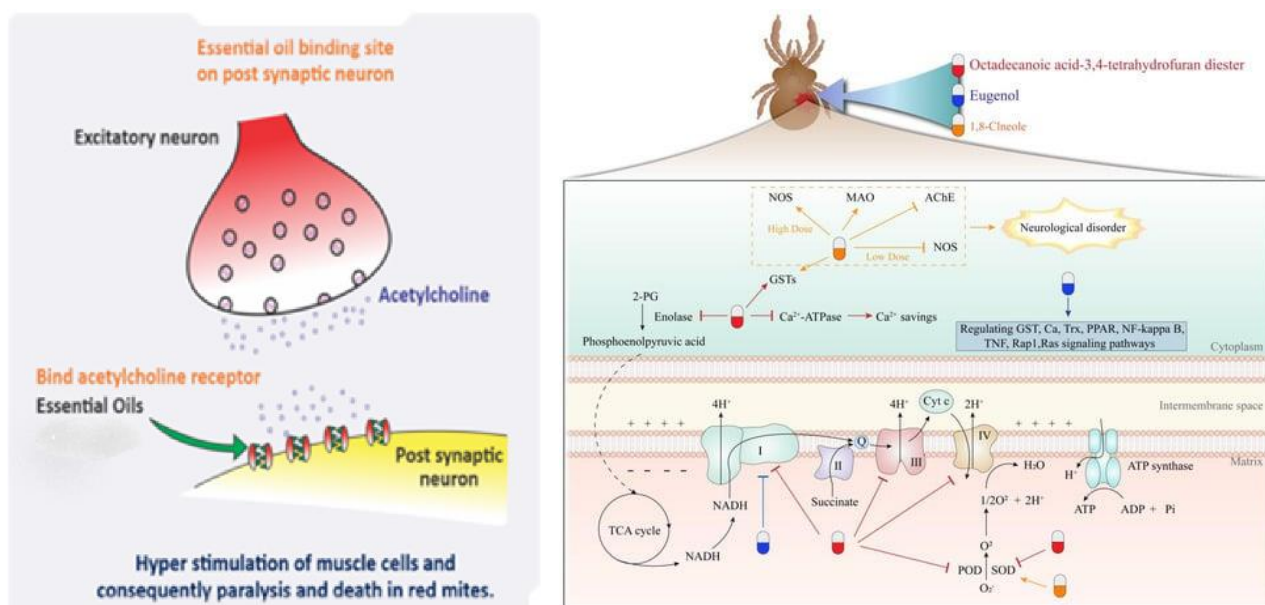


Figure 5. Action mechanism of Demiter Technique.

4. General Acaricidal Mechanism

Acetylcholinesterase is the enzyme responsible for the neurotransmitter acetyl choline esterase activity. The phyto compounds like pinene, carvacrol, limonene menthol, ocimene, eucalyptol, citral, cymene of the essential oils inhibit the acetylcholinesterase activity.

Studies show that this acaricidal neuro toxic effect was due

to an increase in the production of inhibitory catecholamines.

The Demiter Oils show repellent activity [14] on direct contact, the irritated Mite drops off even before its attachment or gets detachment, if already attached to mites, termed as sensu lato repellency, by producing a vapor barrier that deters the arthropod from coming into contact with the skin or landing on the skin. All this possible due to the saponins, tannins, phenolic compound, flavonoids, and alkaloids.

The Demiter essential oils like quinones and polyphenols

have a hydrophobic nature that results in water stress, suffocation, dessication, dehydration, disruption of the waxy cuticular layer and blockage of the respiratory stigma, all this leading the death of mite.

The synergistic strategies of the dusting powder [9], initi-

ated by the powder sticking to the exoskeleton of the mite, its abrasive nature cuts across the cuticular wax, the principal water barrier, the body fluids leak out, leading to dessication and death.

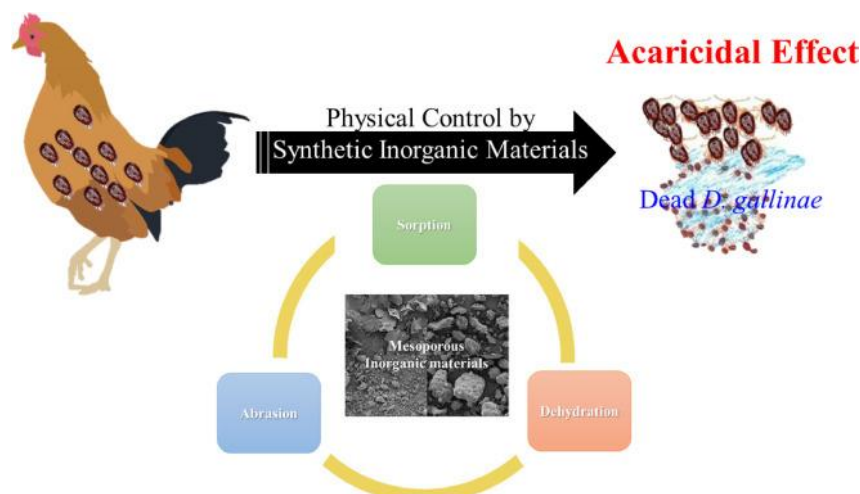


Figure 6. Acaricidal activity of Demiter Technique's Dusting Powder.

The powder once ingested by the mite will cut across the gut epithelium causing intestinal or gut leakages, leading to internal injuries. This effective unique phyto acaricidal demiter technique for the poultry red mite control is a specific, stable innovative combination of herbal essential oils and dusting powder. To work specifically on the target group with no resistance developed.

This technique works at three levels using three different kinds of approaches, [5] the Red mites get repelled by the vapours and the smell of the essential oils, this is Olfactory Avoidance. The Mites relinquish the taste, they get repelled by the taste, this is Gustatory avoidance. When the mites feed on these treated birds, it leads to hyper stimulation of the muscles, binding to the acetylcholine receptors leading to paralysis and mite death.

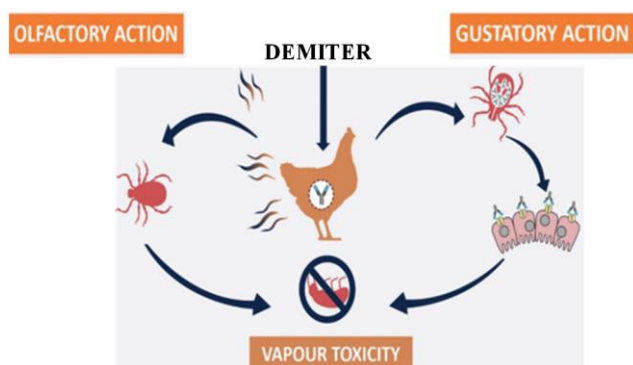


Figure 7. Overall Acaricidal activity of the Demiter Technique.

This extreme repellency leads to starvation and impairing the reproductive performance of the female mites leading to reduction in egg production and also mortality due to the acaricidal property. This also eliminates the multiple overlapping generations, thereby preventing the future resurgence.

5. Conclusion

Poultry red mite can cause various problems to the welfare of the bird, from lesions to growth retardation and death. It has an impact on the egg size, shape, number and also cause egg spotting. All this leading to great economic loss.

The recent advanced Demiter Technique, a phytogenic alternative for the control of red mite, studied, developed and experimented by the R & D of Advanced Aqua Bio Technologies India Private Limited, seems to be a lucrative one since the birds are seen mite free for longer time, working faster and more efficiently than the alternative chemical controls, through its mechanisms of, the sorptive liquid, first removing the epicuticular wax, leading to the epicuticular lipid membrane destruction, causing leakage and dehydration of the mite membrane, followed by the abrasiveness, which further tears the exoskeleton, leading to its death, an effective Acaraine repellent that is non toxic, non hazardous and biodegradable.

Author Contributions

Sujani Gudipati is the sole author. The author read and approved the final manuscript.

Conflicts of Interest

The author declares no conflicts of interest.

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Research Fields

Sujani Gudipati: Animal health, Animal nutrition, Animal herbal solutions, Poultry management, Aquaculture management