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Review article

An overview of ectoparasites in poultry, with particular attention to control challenges and prospects

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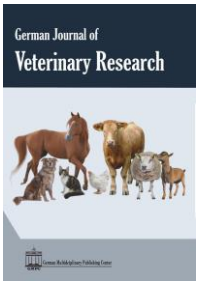

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Abstract

Poultry serve as hosts to a wide variety of ectoparasites, which belong to the phylum Arthropoda. This phylum is divided into two main classes: Arachnida and Insecta. Ectoparasites may remain on the host throughout their life cycle (permanent parasites) or infest the host only for short periods (temporary parasites). Their harmful effects largely depend on their feeding habits. Bloodsucking parasites such as ticks, red poultry mites, and fleas are particularly damaging, as are skin- and scale-feeding species, including various mites and feather lice. Infestations can cause a wide range of health problems in poultry, including anemia, restlessness, itching, feather loss, decreased productivity, and even respiratory disorders. Moreover, many of these parasites can act as vectors of infectious diseases. Poor hygiene and inadequate management practices greatly increase the risk of ectoparasite infestations. The effective control of ectoparasites in poultry remains a critical challenge due to the limitations of conventional chemical treatments, the emergence of resistance, and concerns over environmental and food safety. As the poultry, industry seeks more sustainable and efficient solutions, integrating alternative strategies, such as biological agents, botanical pesticides, physical methods, and novel compounds, offers promising avenues for long-term management. A shift toward integrated pest management (IPM) frameworks that emphasize prevention, reduced chemical reliance, and multi-modal interventions is essential. Continued investment in research, regulatory support, and cross-sector collaboration will be pivotal in developing safe, practical, and economically viable control strategies that safeguard both poultry health and public health. This review provides an overview of the major ectoparasites affecting poultry, their impact on health and productivity, and current strategies for controlling and preventing them.

Keywords: Biological control, Insects, Lice, Mites, Northern fowl mite, Red mite, Scaly-leg mite, Tick

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Introduction

Ectoparasites represent a major health and welfare challenge in poultry production systems worldwide. Belonging to the phylum Arthropoda, these parasites are classified primarily into two groups: Arachnida (mites and ticks) and Insecta (lice, flies, beetles, and fleas) (Brugère-Picoux et al., 2020; Hinkle and Corrigan, 2020; Hernandez-Velasco et al., 2024). Depending on their biology, ectoparasites may be either permanent, spending their entire life cycle on the host, or temporary, feeding on the bird for short periods before returning to the environment. Their feeding habits largely determine their impact on poultry health. Hematophagous parasites, such as ticks, red poultry mites, and fleas, can cause direct blood loss and anemia,

whereas skin- and feather-feeding species, such as chewing lice and feather mites, damage plumage and skin integrity (Murillo and Mullens, 2017; Ameji et al., 2020).

The damage caused by these parasites can vary considerably and may only be evident when the host's health is compromised or the level of infestation is severe. Periodic examination of the flock can help detect infestations early, which is key to successful treatment and preventing a larger outbreak. Heavy infestations in poultry can result in a wide spectrum of clinical problems, including irritation, feather loss, reduced feed intake, decreased productivity, and, in severe cases, respiratory distress or death. Beyond direct harm, many ectoparasites also serve as vectors for bacterial, viral, and protozoal pathogens, thereby compounding their economic and veterinary significance (Hoogstraal, 1985; Walker et al., 2003; Brugère-Picoux et al., 2020). Poor biosecurity, suboptimal hygiene, and limited control measures further exacerbate the risk of infestation in turkey flocks (Kaufman et al., 2000).

The control of ectoparasites in poultry is complex, as it must account for species-specific biology, environmental survival, and the growing concern of resistance to commonly used chemical compounds. Moreover, the presence of pesticide residues in poultry products and the environmental toxicity of acaricides pose additional challenges to public health and sustainability (Zeman, 1987; Beugnet et al., 1997; Nordenfors et al., 2001; Marangi et al., 2009; Katagi and Fujisawa, 2021). This has stimulated interest in exploring alternative strategies, including biological control agents and natural bioactive compounds (Fletcher and Axtell, 1991; Beugnet et al., 1997). This review provides an overview of the most significant ectoparasites affecting poultry, including lice, mites, ticks, beetles, and flies. It describes their biology, pathogenic effects, and transmission routes, and discusses current control strategies alongside emerging perspectives for sustainable ectoparasite management in poultry systems.

Lice

Birds can only be infested by chewing lice (Phthiraptera: Ischnocera and Amblycera), which feed on feathers, feather debris, dry skin scales, scabs, and other types of skin debris, and sometimes on blood extruding from irritated skin (Johnson and Clayton, 2003). Despite being able to chew through feather shafts, they are not true bloodsuckers. Poultry lice are tiny, straw-colored insects with a flattened body, six legs, an elongated abdomen, and a broad, round head. Chewing lice that affect poultry are permanent and obligate, tend to target specific body areas, and are host-specific. Several lice species affect turkeys. For example, the chicken body louse (*Menacanthus stramineus*) (*Amblycera*: *Menoponidae*) is a pale-yellow louse (Figure 1A), measuring 3-4 mm in length. *M. stramineus* has a worldwide distribution and is the most common louse species found on poultry. It is found near the vent, breast, and thigh regions of infested birds. The average egg-laying rate is 1-2 eggs per female per day; their population can increase rapidly and reach pest proportions, mainly on birds with damaged beaks whose grooming ability is significantly impaired (Hernandez-Velasco et al., 2024). *Chelopistes meleagridis* (Large turkey louse) (*Ischnocera*: *Gonoididae*) is a parasite of gallinaceous birds and has a worldwide distribution on domestic and wild turkeys. *C. meleagridis* measures 3.5-3.8 mm in length, has sexually dimorphic antennae and extended temporal lobes, each with one long seta. (Figure 1B). The shaft louse (*Menopon gallinae*) (Amblycera: Menoponidae) is shorter than *M. stramineus*, about 2 mm long. *M. gallinae* remains on the feather shaft longer than in the bird's skin, which is why it is thought to be less injurious (Figure 1C) (Price and Graham, 1997).

The life cycle of poultry lice (egg, three nymphal stages, and adult stage) is spent entirely on the bird. A single female produces between 50 and 300 eggs in her lifetime, which are attached to the feathers. Young lice go through three nymphal stages: Mating of males and females on the host. After an incubation period of 4-7 days, eggs hatch into nymphs that take about three weeks to mature into adults. Infestations can be introduced to a farm through equipment (e.g., crates or egg flats) or other galliform birds (Brugère-Picoux et al., 2020; Hinkle and Corrigan, 2020). Poultry lice typically transfer to new birds by direct host contact. Transmission from one house to another occurs through people, fomites, or flies (phoresis). The diagnosis is based on an external examination of birds around the vent and under the wings. Although chewing lice are relatively benign parasites, when present in large numbers, turkeys can exhibit various clinical signs, including pruritus, lethargy, decreased feed intake, reduced egg

production, weight loss, skin lesions, and ragged-looking feathers (Booth et al., 1993). Lice can be controlled with insecticides such as pyrethrins, pyrethroids, organic phosphoric acid esters, carbamates, and triazines. Eggs are not killed, so treatment should be repeated after 10-14 days.

Mites

Mites are a numerous group of symbionts associated with birds. They are specialized to particular microhabitats on avian tissues. Mites are not always specific to one host. Mite parasites feed on blood, feathers, skin secretions, and skin scales (Figure 2). Although mites have a minuscule size (0.3 to 1.5 mm), they are visible to the naked eye. Their bodies are not segmented, and they possess oral appendages and eight legs (Hernandez-Velasco et al., 2024). Their life cycle consists of four stages: eggs, larvae, nymphs (protonymph and tritonymph), and adults (Figure 3).

Northern fowl mite

Ornithonyssus sylviarum (Figure 4A) is widely distributed throughout temperate regions of the world. It is a parasite of poultry and wild birds, is <0.5 mm long, and is a hematophagous (blood sucking) mite that tends to congregate around the vent. They spend most of their life cycle on the host. Tens of thousands of mites can infest a single animal, causing skin inflammation, irritation, scabbing, anemia, and discoloration of feathers around the vent. Northern fowl mites can hide in cracks and crevices and survive outside hosts for several weeks, depending on weather conditions. It is essential to note that young birds are particularly susceptible to illness. Additionally, rodents and wild birds can serve as reservoirs for the mites. The mites can also infect humans when poultry workers handle infested birds (Brugère-Picoux et al., 2020; Hinkle and Corrigan, 2020). The life cycle of mites typically occurs within about one week on the host (typical parasites). The adult will feed several times during its lifespan of 3-7 days (Murillo and Mullens, 2017). A dark discoloration of feathers around the vent may be observed if a bird is heavily infested with mites. Moreover, the bird's skin may become irritated, leading to secondary bacterial infections.

Figure 1: Morphology of the most common lice affecting poultry. A) Dorsal view of a female *Menacanthus stramineus*. Note that each abdominal segment has two rows of setae. B) *Chelopistes meleagridis*, ventral view. Note the thin antennae and the bifurcation on the last abdominal segment characteristic of females. C) Ventral view of a male of *Menopon gallinae*. Note that each abdominal segment has one row of setae.

Figure 2: A) *Ornythonyssus sylviarum* in the feathers and skin of the perianal region of a backyard hen. B) Severe *Knemidocoptes mutans* infestation in the legs of a backyard rooster. C) *Menacanthus stramineus* nests on the feathers of a backyard hen.

Figure 3: Life stages of mites. Egg (e), larva (l), protonymph (p), tritonymph (t), and adult (a).

Red mite

Dermanyssus gallinae (red poultry mite) is common in the Palaeartic region and in the United States of America. It is also a hematophagous mite, but not a permanent ectoparasite (nocturnal). It feeds at night and lasts only 30 to 60 minutes. Blood-feeding stages (adult and nymphal mites). They can hide in nearby cracks and crevices, where the mites deposit their eggs. The life cycle is similar to that of the Northern fowl mite; however, adult red mites can live for nine months in the environment without feeding (Hernandez-Velasco et al., 2024).

Red mites can cause several problems, including i) a drop in egg production and reduction of fertility, and ii) a negative impact on feed conversion efficiency. iii) In severe cases, it causes anemia and increases mortality, particularly among younger birds. iv). It might act as a carrier for viral and bacterial pathogens such as NewCastle disease virus (NDV), avian pox, Western equine encephalitis, *Salmonella, E. coli, Borrelia*, and erysipelas (Brugère-Picoux et al., 2020). Additionally, red mites can infest or attack humans, causing small red lesions and intense itching. It is not easy to detect this mite with the naked eye. However, infested birds show nervousness, pecking, stress aggregation, and reduced performance. Glue traps or corrugated cardboard tubes can be used for mite detection. These mites are grayish or red, indicating that they have already fed on blood, and are extremely similar to mites of other species, so they must be clarified for identification. The identification features are the end of the dorsal shield that does not reach the posterior end of the body, the anus is located in the posterior half of the anal shield, which is wedge-shaped, and the chelicerae are long and styliform (McCrea et al., 2005) (Figure 4B). The distinction between *O. silvyarum* and *D. gallinae* is extremely important, as their distinct behaviors require different control measures. The high cost of control and treatment highlights the economic impact of mites in both organic and conventional egg production.

***Knemidocoptes mutans* (Scaly-leg mite, Depluming itch mite)**

Poultry can be infected by small mites known as scaly leg mites (*Knemidocoptes mutans*, Figure 4C) (Ameji et al., 2020). This parasitosis is more common in birds kept in semi-free conditions or backyard settings. These mites are permanent parasites, with a lifespan of approximately two weeks. These mites can burrow into the skin, particularly in unfeathered areas such as the feet, leading to inflammation, enlarged and protruding scales, and leakage of lymphatic fluid. Scaly leg mite infestations can cause leg and claw deformities when left untreated. Unlike mammals, birds may exhibit intense itching (Brugère-Picoux et al., 2020; Hinkle and Corrigan, 2020). The diagnosis is confirmed through microscopic observation of scale scrapings. These mites are tiny (140-495 µm in diameter) and may not be visible without magnification. They are almost round with very short legs, and may exhibit pronounced sexual dimorphism, including a difference in size between the sexes, and the presence of two distinctive longer setae in the male (Figure 4D). Scaly leg mites can be treated with pesticides or by dipping the affected limbs in a mixture of linseed oil and kerosene every week until the problem subsides. In some cases, veterinarians may recommend off-label ivermectin for the treatment of scaly leg mites (Hernandez-Velasco et al., 2024).

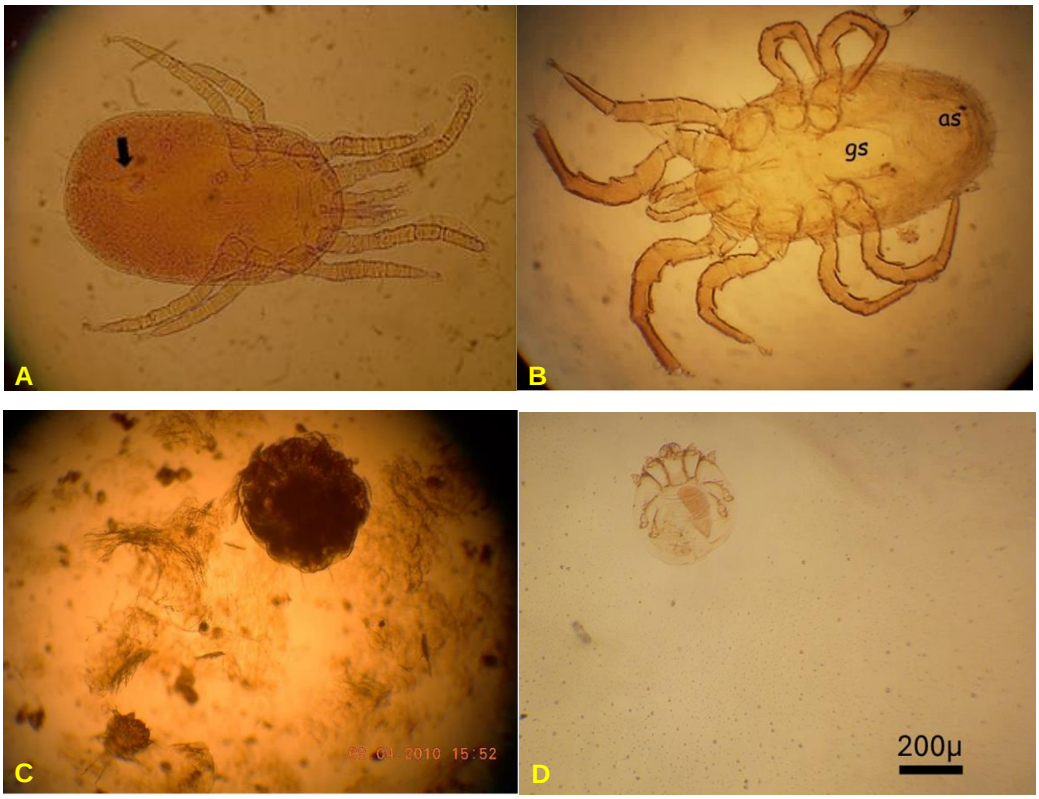

Figure 4: Mite in poultry. A) Ventral view of a cleared female *Ornithonyssus sylviarum*, showing the teardrop-shaped anal plate distinctive to this genus (arrow). B) Adult female of *Dermanyssus gallinae*, overview of the ventral side. Note the genitoventral shield (gs) is broadly rounded posteriorly, and the anal shield (as) is keystoneshaped with a posteriorly located anus. C) Female (top right) and male (bottom left) of *Knemidocoptes mutans* from a sample taken directly from the bird. D) Adult clarified female of *Knemidocoptes mutans,* ventral view.

Subcutaneous mites

The subcutaneous mite, *Laminosioptes csyticola* (*Sarcoptiformes*: *Laminosioptidae*), is mostly found in the subcutaneous layer and on the surface of the muscles of several birds, particularly Galliformes (chickens, turkeys, and pheasants) and Columbiformes (pigeons and doves). It has also been reported in the lungs, peritoneum, and abdominal viscera. The life cycle is poorly understood (Martins et al., 2010). According to Moretta et al. (2025), female *L. cysticola* is larviparous. *L. cysticola* is oval-shaped, slightly wider posteriorly, with two long caudal setae. The first two pairs of legs are more robust than the last two. The female mites, measuring 0.11 × 0.25mm in length, lay eggs in the subcutaneous tissue, where they develop. Adult and newborn mites feed on soft tissues and then die. The parasite can be detected only by the presence of small, flat, oval nodules in the subcutaneous tissue. These nodules contain a caseous or calcified center, formed around dead mites, and are known as nodular acariasis (Tavakkoli et al., 2018). *L. cysticola* is distributed worldwide; however, its presence in birds is rare and has been reported primarily in rural backyard poultry farms, where unfavorable environmental and immunological conditions significantly contribute to the clinical manifestation of the infestation.

***Neoschoengastia gallinarum* (Chiggers)**

Neoschoengastia gallinarum (Arthropoda: Arachnida: Acarina: Trombiculidae) was first described in Taiwan by Sugimoto (1936). The life cycle of chigger mites is incomplete metamorphosis and consists of four stages: egg, larva, nymph, and adult (Jeu, 1961). The larvae feed on the blood of many bird species, including poultry. They primarily parasitize under the wing and medial side of the thigh. After falling off the host, they develop into nymphs. After the larvae have fed (typically for 4–6 days), they drop off the turkey, and subsequent life stages are non-parasitic. It causes anemia, emaciation, and economic losses due to carcass downgrading. Chigger-damaged areas must be removed at

slaughter (Brugère-Picoux et al., 2020; Hinkle and Corrigan, 2020).

Control of mites

Mite control is based on biosecurity and the use of acaricides. The main difficulty in treating mites is ensuring that the acaricides reach the areas where the mites are present, as even the strongest ones are only effective if they make contact with the mites.It is important to apply acaricides directly to the infested area, as these mites are mostly found around the vent region (Kaufman et al., 2000). Different types of acaricides have proven effective in controlling poultry mites. These include organophosphates such as tetrachlorvinphos, dichlorvos, and malathion; synthetic pyrethroids such as permethrin and deltamethrin; and carbamates such as carbaryl (Fletcher and Axtell, 1991). However, it has been found that ivermectin is not an effective control of poultry mites (Beugnet et al., 1997). Mite suppression can be challenging due to the development of acaricide resistance in mite populations. In addition to strict hygienic measures, using several products, such as phoxim and spinosad, can also be beneficial. *Androlaelaps casalis* and *Cheyletus eruditus* can also be used as biological controls for red mites.

Ticks

Poultry can be affected by two types of ticks: soft, such as *Argas* spp., and *Ornithodoros* spp. (Ixodida: Argasidae) or hard (*Ixodes* spp., *Amblyomma* spp., *Hemaphysalis* spp.) (Ixodida: Ixodidae). Among these, *Argas* spp., commonly known as the fowl tick (Kohls et al., 1970), are important poultry pathogens. They have a flattened body margin, a lateral sutural line, and a leathery, folded cuticle (Figure 5A). Ticks occur worldwide, primarily in humid tropical and subtropical regions, and are not host-specific, parasitizing all classes of terrestrial vertebrates, including amphibians, birds, reptiles, and mammals.

They can survive for several years without food, hiding in cracks or crevices, but come out at night to feed on blood (Hoogstraal, 1985), similar to the northern fowl mite. The female tick lays up to 500 eggs in masses of 25 to 100 in these concealed crevices, which can take two weeks to several months to hatch, depending on the temperature. Larvae typically feed slowly and remain attached to their host for 5 to 10 days. Nymphs (Figure 5B) and adults feed on blood for short periods during the night and spend most of their time off the host, hiding in crevices or cracks. Each life stage requires a successful, rapid blood meal to moult. Nymphs feed multiple times and molt until they mature as males or females (Sonenshine, 1991; Walker et al., 2003; Vial, 2009). The adult female can consume up to 0.3 mL of blood per feeding. Ticks cause emaciation and fatal anemia. Birds may also develop tick paralysis, which is characterized by flaccid paralysis of the bird. In addition, ticks transmit several pathogens, including *Borrelia anserina*, Rickettsia (*Aegyptianella pullorum*), and *Pasteurella multocida* (Taylor et al., 2007; Estrada-Peña et al., 2004), to domestic and wild animals, as well as to humans.

Figure 5: Morphology of ticks. A) Ventral view of an adult of *Argas persicus*. Note the hypostome (ventral oral plate) that allows it to anchor to the host while sucking blood firmly. B) Nymph of *Amblyomma* spp. dorsal view.

It is challenging to eradicate argasid tick infestations because adults can survive for over a year without feeding on a host, due to their high resistance to starvation. This makes it challenging to eliminate them from infested areas. It may be necessary to repeat the treatment to prevent any remaining eggs from hatching and producing more larvae (Hinkle and Corrigan, 2020).

Fleas

The sticktight flea, *Echidnophaga gallinacean* (*Siphonaptera*: *Pullicidae*), is one of the smallest fleas found on domestic animals (1-2.5mm). It is distributed globally. The sticktight flea is dark brown, with an angled head and a laterally flattened body (Figure 6). Infested poultry have clusters of fleas on featherless areas of the head, around the eyes, combs, and wattles. The fleas have their heads embedded in the host's skin and cannot be easily removed. They can be removed with tweezers by grasping them firmly and pulling them out. Fleas cause skin irritation when they feed; therefore, an antibiotic ointment should be applied to the affected area to prevent infection. In large numbers, they can cause the eyes to swell shut. Young animals are most affected and may die of starvation or succumb to anemia caused by flea feeding (Hernandez-Velasco et al., 2024). The female lays her eggs on the feathers, which fall to the ground. The eggs hatch within six to eight days after being laid. The white larva feeds primarily on dried adult feces. It progresses through three larval stages in seven to fourteen days, then spins a small cocoon and pupates. The adult flea emerges after a week, ready to feed on blood. Adult fleas are vulnerable to treatment, but re-infestation can occur in environments where eggs and larvae develop. It is recommended to treat the facilities to eliminate larval development and to burn infested organic material to prevent re-infestations.

Flies

Flies pose significant challenges in poultry production systems, being among the most economically important ectoparasites affecting birds. The most common fly species encountered in poultry environments include the house fly (*Musca domestica*) and the little house fly (*Fannia* spp.). Their presence on farms not only increases stress among poultry and farm workers but also negatively impacts productivity and overall biosecurity.

House flies (*Musca domestica*) are particularly problematic due to their role as mechanical vectors and intermediate hosts. They can transmit a wide range of poultry pathogens, including *Salmonella, Campylobacter* (Royden et al., 2016; Thomson et al., 2021), avian influenza virus, *Histomonas meleagridis* (histomoniasis), and turkey coronavirus (Calibeo-Hayes et al., 2003; Wanaratana et al., 2013). Moreover, house flies have been identified as potential carriers of antimicrobial-resistant (AMR) bacteria, contributing to the spread and maintenance of antimicrobial resistance on farms (Alves et al., 2018; Fukuda et al., 2019; Gwenzi et al., 2021; Bertelloni et al., 2023).

Other fly species also play important roles in disease transmission. Black flies (family *Simuliidae*) and biting midges (*Culicoides* spp.), both distributed globally, are vectors of *Leucocytozoon* spp., protozoan parasites that can cause disease in birds (Yu and Wang, 2001; Brugère-Picoux et al., 2020). These blood-feeding flies can trigger outbreaks of leucocytozoonosis, especially in outdoor or free-range systems.

The black soldier fly (*Hermetia illucens*) is more commonly associated with poor waste management, particularly in facilities where manure and litter accumulate over extended periods. While the larvae of this species are often used in sustainable waste conversion and animal feed production, in unmanaged environments, they can accelerate the liquefaction of manure, leading to nutrient loss and leakage and ultimately reducing the value of poultry fertilizer (Brugère-Picoux et al., 2020).

Mosquitoes, particularly species from the genera *Aedes* and *Culex* (Diptera: *Culicidae*), are also important vectors in poultry. *Culex pipiens* and *Culex quinquefasciatus* are known to transmit avian malaria (*Plasmodium* spp.), while *Aedes aegypti* and *Aedes stimulans* are involved in the transmission of fowl pox virus (Lüschow and Hafez 2024). Additionally, mosquitoes can contribute to the spread of other viruses such as Eastern and Western equine encephalitis (EEE and WEE), further emphasizing their importance in poultry health management (Shehata et al., 2025).

Figure 6: Male *Echidnophaga gallinacea*. Note its sharply angled squarish head and absence of both pronotal and genal ctenidia. Its mouthparts are well adapted for piercing and sucking.

Challenges in controlling ectoparasites and future perspectives

The control of ectoparasites in poultry, including mites and lice, primarily relies on chemical acaricides such as organophosphates, pyrethroids, carbamates, and triazines. However, their effectiveness is increasingly limited due to several inherent challenges. i) Certain parasites, like the poultry red mite (*Dermanyssus gallinae*), are notoriously difficult to treat. These mites hide in dark, narrow crevices during the day, rendering them inaccessible to conventional chemical treatments. ii) Resistance is also a growing problem. Resistance to permethrin, amitraz, and carbaryl has been reported in poultry mite populations (Zeman, 1987; Beugnet et al., 1997; Nordenfors et al., 2001; Marangi et al., 2009). iii) Manual dusting treatments are labor-intensive and stressful for birds, as each animal must be handled individually, and the dust must be directed precisely to the infestation sites. These procedures risk causing injury or distress to the birds. iv) Poultry feathers are naturally water-repellent, making it difficult for aqueous pesticide sprays to penetrate the plumage adequately. This often results in poor efficacy and product wastage. v) Another significant concern is the toxicological impact of these chemicals. Birds are more susceptible to pesticide toxicity than mammals due to lower detoxification enzyme activity (Katagi and Fujisawa, 2021). Additionally, chemical residues in eggs and meat pose a public health risk. For instance, Alaboudi et al. (2019) found that 96% of eggs sampled in Jordan contained pesticide residues, with 66.5% exceeding maximum residue limits (MRL). Similarly, cypermethrin was detected in 52% of egg samples, making it the most frequently detected contaminant (Dallegrave et al., 2018). These findings underscore the urgent need for safe, residue-free alternatives to manage ectoparasites in poultry (Hwang, 2023).

Exploring novel acaricides

Research efforts have long aimed to identify effective alternatives to conventional acaricides. One such candidate is thuringiensin, an exotoxin produced by *Bacillus thuringiensis*. It compromises the integrity of the mite cuticle, leading to impaired movement in *D. gallinae* (Torres et al., 2018). Despite its efficacy, thuringiensin also inhibits RNA polymerase activity, rendering it highly toxic and raising safety concerns about its use in poultry farming (Sparagano et al., 2014; Wiest et al., 2015).

In contrast, spinosad, a naturally occurring compound derived from the fermentation of *Saccharopolyspora spinosa*, has shown significant effectiveness in controlling poultry red mites. Approved under the trade name Elector® since 2010 in several EU countries, spinosad provides a viable non-synthetic option for mite control (George et al., 2010).

Fluralaner, an isoxazoline compound, has demonstrated effectiveness against mite and bed bug infestations in poultry (Elliot et al., 2024). It

targets gamma-aminobutyric acid (GABA) and glutamate-gated chloride channels located in both the central nervous system and peripheral neuromuscular junctions of arthropods. Notably, no resistance or cross-resistance with existing antiparasitic agents has been reported, and studies have demonstrated a broad safety margin in both dogs and poultry (Hinkle et al., 2018). Fluralaner is commercially available as Bravecto® (Merck Animal Health, Rahway, New Jersey, USA), approved for oral administration in dogs and transdermal use in both dogs and cats for the treatment of fleas and mites; however, it has not yet been approved for use in poultry in the United States. Nonetheless, several studies support its efficacy and safety in treating poultry parasites, including mites and bed bugs (Huyghe et al., 2017; Hinkle et al., 2018; Gonzalez-Morales et al., 2022). In Europe and Australia, the use of fluralaner (marketed as Exzolt® by Merck Animal Health) is approved for managing *Dermanyssus gallinae* in pullets, breeders, and laying hens, using a dosage of 0.5 mg/kg administered twice via drinking water, with a seven-day interval between doses (European Medicines Agency, 2025; Australian Pesticides and Veterinary Medicines Authority, 2019). A recent study evaluated the pharmacokinetics and bioavailability of fluralaner in healthy Shaver hens following intravenous (0.5 mg/kg) and transdermal (mean 58.7 mg/kg, Bravecto®, Merck Animal Health, Madison, New Jersey, USA) administration. Plasma samples were analyzed using UPLC/MS, revealing elimination half-lives of 80.5 hours (IV) and 179.6 hours (transdermal), with a transdermal bioavailability of 3.4%. Both routes maintained plasma levels above the minimum inhibitory concentration for bed bugs, indicating potential for poultry use, pending regulatory approval (Elliot et al., 2024).

Lithium chloride, a salt already proven effective against Varroa mites in beekeeping, has recently shown potential in controlling *D. gallinae*. Early results are promising, but additional research is needed to confirm its suitability in poultry environments (Kolics et al., 2022).

Volatile organic compounds

Numerous studies have highlighted the potential of volatile organic compounds (VOCs), including pheromones, kairomones, and plant-derived VOCs found in essential oils and extracts, in controlling poultry red mites (*Dermanyssus gallinae*). Pheromones and kairomones act as natural attractants and, when combined with acaricides, can enhance the effectiveness of attract-and-kill mite traps (Gay et al., 2020).

Plant-derived essential oils (EOs) are gaining attention as promising candidates due to their biodegradability, safety, and broad-spectrum activity. Several studies have reported their high efficacy against poultry ectoparasites. For instance, ginger and citronella EOs showed strong activity against lice (*Menopon gallinae*) and mites (*Ornithonyssus bursa*) (Vigad et al., 2021), while clove, cinnamon, and turmeric EOs achieved complete mortality of lice (*Lipeurus caponis*) within 12 hours of exposure (Pumnuan et al., 2020). The pesticidal potential of EOs is largely attributed to their bioactive compounds (Isman, 2006). Among these, eugenol, found in clove and cinnamon, exhibits potent insecticidal, acaricidal, and ovicidal activities (Fichi et al., 2007a; Abenaim et al., 2022). Notably, eugenol has been shown to effectively inhibit egg development in *Sarcoptes scabiei* (Li et al., 2021). Furthermore, clove and cinnamon EOs, as well as their active constituents, have been proposed for use in the development of fumigants, repellents, and attractants targeting the poultry red mite, *Dermanyssus gallinae* (Sparagano et al., 2022; Lee et al., 2019).

The essential oil of *Artemisia sieberi* (commonly known as desert wormwood) has been shown to effectively repel adult mites, alongside oils from garlic, thyme, and lavender, which also exhibit acaricidal activity (Puvača et al., 2018; Tabari et al., 2017). A commercial product, red mite avian (Lentypou+), containing extracts of *Thymus* spp., *Arctium* spp. (burdock), Furthermore, *Tanacetum vulgare* (tansy) is believed to make host blood unpalatable to mites, potentially leading to starvation (Sparagano et al., 2014). This approach is further supported by findings suggesting that starving mites become more vulnerable to both essential oils and conventional synthetic acaricides (George et al., 2008). Another example is Mite-Stop® (Vichte, Belgium), which utilizes neem oil and has demonstrated superior efficacy compared to ByeMite® (Cuxhaven, Germany), a phoxim-based synthetic acaricide (Abdel-Ghaffar et al., 2009). Collectively, these findings underscore the promising role of plant-derived VOCs as eco-friendly alternatives in managing red mite infestations. To enhance the efficiency of botanical pesticides, nanoemulsion-based plant

essential oil formulations (NEOFs) are recommended, as nanoemulsions have been shown to increase stability compared to pure essential oils significantly (Firooziyan et al., 2022).

Biological control

Biological control of ectoparasites through the introduction of natural predators or entomopathogenic microorganisms presents a promising alternative to chemical treatments. Several predatory mite species, such as *Androlaelaps casalis, Hypoaspis aculeifer*, and *Hypoaspis miles*, have been identified in environments commonly inhabited by *D. gallinae*, such as bird nests. These predators feed on poultry red mites and can reduce their populations in infested areas. However, their effectiveness under field conditions may be limited by environmental variability and the potential availability of alternative prey (Lesna et al., 2009).

Entomopathogenic microorganisms, including fungi and bacteria, provide an alternative biological control approach by infecting and killing mites. Certain fungi, such as *Beauveria (B.) bassiana, Trichoderma (T.) album, Paecilomyces fumosoroseus, Metarhizium anisopliae*, and *Aspergillus oryzae*, have demonstrated variable levels of efficacy against *D. gallinae*. For instance, a combination of *M. anisopliae* and *B. bassiana* resulted in 61.7% mite mortality under field conditions, while *B. bassiana*, when used with *T. album*, achieved up to 80% mortality within 10 days. When incorporated into fungus-based traps, these fungi demonstrated even higher efficacy, achieving 80–100% mite mortality in some trials (Silva et al., 2023; Ebani et al., 2021). Independently, *B. bassiana* has shown strong potential, with lab studies reporting over 70% mortality depending on the application method, and field trials showing population reductions of 65–90% using autoinoculation devices or sprayed conidial suspensions (Nascimento et al., 2020; De Oliveira et al., 2020).

Among entomopathogenic bacteria, *Bacillus thuringiensis* stands out for producing insecticidal proteins, including crystal proteins, exotoxins, and proteases. Its effectiveness varies with dosage and exposure time, but reported mortality rates range between 60% and 80%, suggesting it may be a viable candidate for biological mite control (Ebani et al., 2021).

Physical approaches

Beyond chemical and biological approaches, physical control methods offer valuable support in reducing infestations of *Dermanyssus gallinae*. Key strategies include thermal treatments, in which high or low temperatures are applied in empty poultry houses to kill mites; altered lighting patterns, which disrupt mites' nocturnal behavior; and the application of inorganic materials, such as diatomaceous earth (DE), kaolin, and silica-based powders. These substances work by damaging the mites' outer layer, leading to dehydration, and also create an environment that hinders their mobility (Hwang et al., 2023; Ulrichs et al., 2020).

Environmental control is another essential aspect, focusing on minimizing areas where mites can hide and reproduce. This involves identifying and eliminating small cracks, crevices, or other structural features in poultry housing that serve as harborage sites for mites. Although this process can be time-consuming, it significantly reduces the chance of re-infestation. Moreover, maintaining strict hygiene and sanitation protocols, though sometimes underestimated, is fundamental to any long-term mite prevention strategy (Sparagano et al., 2014).

Conclusion and prospects

Despite the pursuit of novel tools, existing control measures should remain part of the management strategy. Effective ectoparasite control requires an integrated approach, with prevention as the foundation, alternative non-chemical methods as the main structure, and chemical interventions as a last line of defense. This layered strategy is central to IPM, which, although initially resource-intensive, offers long-term benefits such as reduced infestation rates, improved animal welfare, and lower reliance on chemicals. Monitoring and detection systems should be enhanced through automation and integrated data tools that enable real-time decision-making. Continued exploration of alternative control methods is essential, particularly the optimization of biological agents, refinement of attractant-based traps, and improvement of physical interventions. Additionally, standardized methods for assessing the economic impact of infestations are necessary to accurately evaluate the cost-effectiveness of control strategies.

Collaboration between scientists, producers,

and industry stakeholders will be crucial to turning research findings into practical solutions. Facilitating knowledge exchange among these groups can accelerate the adoption of effective practices and support the development of field-ready technologies. With coordinated efforts and sustained innovation, the poultry industry will be better equipped to manage ectoparasites more efficiently and in a more environmentally responsible manner.

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