

Chewing Lice (Insecta: Mallophaga) on Chickens, Poultry and Other Domestic Birds in Consort with Biology, Prevention and Control

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Abstract

Almost all chickens *Gallus gallus* Linnaeus have external parasites and lice are the most common pests crawling on skin under feathers, and can cause problems when their load explodes. Chickens with lice may go off their feed, lose weight, reduce egg laying, experience feather loss and generally look unthrifty. This article is designed to improve understanding of poultry louse infections, how to spot an infestation, how lice operate in poultry and the variety of treatment options available. There are many different species of lice that can infest chickens including chicken body louse (*Menacanthus stramineus*), shaft louse (*Menopon gallinae*), fluff louse (*Goniocodes gallinae*), wing louse (*Liperus caponis*) and chicken head louse (*Cuclotogaster heterographus*). Of these, the most common type of lice that chickens suffer from and probably most common species is *M. gallinae*. All of these lice are permanent ectoparasite of domestic chickens and they complete their entire life cycle on the host. The chicken body louse can reach problematic levels regardless of housing or production type (caged, cage-free, free-range or backyard poultry). The other listed species are rare or unknown to infest commercial poultry, but have been documented on backyard chickens worldwide. Chicken lice feast on feathers, scales of dry skin and any sores on the bird. Unlike to other types of lice, they do not actually suck the chicken's blood per se, but only feed on blood from lesions the bird acquires by other means. Signs and symptoms of infected chickens are a drop in egg production, broken feathers, feather loss, over preening, red or sore skin around the vent area, scratching, lice crawling around the shaft of feathers, and whitish grey nits (clumps of eggs stuck to the bottom of feather shaft, but most commonly around the vent area). Lice live on chicken's skin underneath feathers, so the entire life cycle happens on host and it is much easier to treat lice compared to other parasites. In small numbers, lice do not cause much irritation to chickens and they try to manage their lice by having dust baths, which will suffocate lice. However if chickens have large numbers of lice living on them then they will need a bit of extra help from their owner. As a preventative method, it is a good idea to sprinkle diatom powder in chickens dustbaths (or over area they usually use for dustbaths) as this will keep lice from being able to take hold. If there are lots of lice then use a lice powder to powder chicken all over working it into their feathers and skin 3-4 times a week for 3 weeks until chicken is lice free. In the mornings owners can also dust their chicken coop with powder although be careful to not make it too dusty as dust can cause respiratory problems. Lice are best controlled on caged chickens by spraying with pyrethroids, carbaryl, coumaphos or malathion. Birds on floor are more easily treated by scattering any of these dusts on litter. As louse eggs are not killed, so insecticide treatment should be repeated after 10 days interval.

Keywords

Parasitic Lice, Pediculosis, Poultry Lice, Chicken Lice, Ectoparasite, Backyard Poultry, Parasite

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1. Introduction

The lice (singular: louse) are obligate parasites, living externally on warm-blooded hosts among the hairs or feathers, and feed on their skin and debris, or pierce the host's skin and feed on blood and other secretions [1-4]. Chicken lice are tiny, flat, skin colored, wingless, and have an elongated abdomen and mouthparts with which to chew on the host bird. Lice generally feed on skin particles and feathers, but do not have sucking mouthparts and unable to feed on blood. When examining a bird for lice they are usually found on the skin around the vent and under the wings [5].

All lice species that affect poultry and most domestic birds belong to the group of Mallophaga or bird lice. About 3000 species of Mallophaga (biting-lice) are in the world and they are an unfortunate fact of life with chickens. There are more than 40 species worldwide and most of them are cosmopolitan, i.e., they occur almost everywhere. In most cases infested birds carry lice of several species simultaneously. Many species infest poultry as well as other domestic birds such as turkeys, pigeons, guinea fowls, ducks, geese, etc., and wild birds too, i.e., they can re-infest each other if they come in contact. They are easily identifiable by their heads, which are wider than their prothoraces. The species that feed on birds typically have two claws at the end of each tarsus, while those that feed on mammals typically have just a single claw. Avian lice, which belong to the order Mallophaga, have a life cycle of 3 wk and normally feed on bits of skin or feather products. Lice may live for several months on the host, but only remain alive for 1 wk off the host. People and other mammals may harbor avian lice, but only temporarily [6].

In intensive poultry systems, the most common and economically important louse to bother chickens and turkeys is *Menacanthus stramineus*, the chicken body louse, which typically is found on the breast, vent and thighs. It punctures soft quills near their base or gnaws the skin at the base of the feathers and feeds on the blood. Chickens are less commonly infested with *Menopon gallinae* (on feather shafts), *Lipeurus caponis* (mainly on the wing feathers), *Cuclotogaster heterographus* (mainly on the head and neck), *Goniocotes gallinae* (very small, in the fluff), *Goniodes gigas* (the large chicken louse), *Goniodes dissimilis* (the brown chicken louse), *Menacanthus cornutus* (the body louse), *Uchida pallidula* (the small body louse), or *Oxylpeurus dentatus*. Turkeys may also be infested with *Chelopistes meleagridis* (the large turkey louse) and *Oxylpeurus polytrapezius* (the slender turkey louse) [7].

Because lice transfer from one bird species to another when

the hosts are in close contact, other domestic and caged birds may be infested with species of Mallophaga that are usually host-specific. Lice also sometimes reach to new bird hosts by using louse flies (Hippoboscidae) for transportation. Some lice of geese and swans are vectors of filarial nematodes. Heavy populations of the chicken body louse decrease reproductive potential in males, egg production in females and weight gain in growing chickens. The skin irritations are also sites for secondary bacterial infections. Other species of lice are not highly pathogenic to mature birds, but may be fatal to chicks. Examination of birds, particularly around the vent and under the wings, reveals presence of eggs or moving lice on the skin or feathers. Lice are usually introduced to a farm through infested equipment (crates or egg flats) or by galliform birds [8].

Lice are considered external parasites and they feed off of the host, from the outside, like mites or fleas. Some are tiny while others are large enough to see with the naked eye. Poultry lice feed on a chicken's dead skin, their blood, feather shaft debris and anything else they find appetizing on a chicken. A louse spends its entire life-cycle living on an unsuspecting chicken, usually under the feathers and near the vent. There are several species that may be found on chickens, turkeys, ducks and other fowls. When eggs are laid, they attach to the host's feathers. The generation time is from two to seven weeks depending on the species. The entire life cycle of the louse is spent on the host unless by chance the insect is disturbed and happens to be found on a human or other animals [9].

They spread fast and can cause severe problems for the entire flock. Lice spread easily from chicken to chicken, so bringing any new chickens into a flock can be dangerous if they are not quarantined and monitored before introducing them to their new feathered friends. Identifying of an infestation early and treating the flock quickly, is extremely important to prevent a decline in health and in some cases death. Generally, chickens can handle a few mites here and there, but often dust baths will stifle an infestation. As usual, a chicken takes pretty good care of itself and knows when a dust bath is in order when they are overrun with lice. Lice multiply quickly and an out-of-control infestation means a chicken is being fed upon by many lice; thus the chook runs the risk of becoming anemic, due to blood loss. An anemic chicken has a weakened immune system and can easily contract to other infections and diseases, wherein if the condition is not treated, it can often lead to death [10].

Poultry lice cannot infest humans; unlike human lice, poultry lice feed on feathers and poultry skin. But only a little, poultry lice will bite to humans, leaving itchy red marks, so take extra precautions when handling of infested birds, and

wear gloves, a long-sleeve shirt, boots and trousers when inspecting of flock. At the very least, chicken have an uncomfortable when scratching and pecking at herself, for seeking relief. If chicken seems to be preening themselves with more vigor than normal, it is time to inspect them, especially around their vents, under their wings, on their breasts and down around the base of their feather shafts. Red patchy areas and chewed-looking shafts are an indication of a lice infestation. Clusters of white eggs are another telltale giveaway. Other signs include feather loss; pale wattles and combs, indicating anemia; a drop in egg production; lack of weight gain in chicks and juveniles; and a fluffed-up, sick appearance [11].

The simplest way to suppress a lice infestation is to offer the birds a large, deep dust bath containing play sand and food-grade diatomaceous earth or DE. Use a mixture of approximately six cups of DE to 25 pounds of play sand. The DE will desiccate any poultry lice it touches and help to prevent infestations by lice and other ectoparasites. For more severe infestations, use a pyrethrin-based insecticide. Pyrethrin-based insecticides are available as sprays, solutions and dusts [12].

2. Kinds of Poultry Lice

There are two kinds of lice: biting and bloodsucking. Blood-sucking lice attack only mammals, but biting lice infect both birds and mammals. Poultry lice are species-specific and cannot survive on humans. These are known as ecto-parasites or external parasites as they live on the outside of the bird. Just as there are three types of human lice, there are multiple kinds of poultry lice. There are 40 to 50 species of lice found on domestic poultry. They are all soft and flattened bodied and pale-coloured insects. None suck blood, but they do have mouth parts that chew on feathers and scales from the skin. If there is a large population of lice living on hen, they will cause irritation and can be so annoying that the bird will fail to thrive. The order Mallophaga is divided into the suborders Ischnocera, Amblycera and Rhynchophthiria. Only one species, found on elephants, comprises in the Rhynchophthiria. The Ischnocera and Amblycera are found on both mammals and birds. In general, the members of the Ischnocera, which live on birds are found on the feathers and their diet consists mainly of feathers. Twelve valid species of chewing lice have been recognized in domestic chickens (*G. gallus*) [5]. These include four amblyceran species *Menacanthus cornutus*, *M. stramineus*, *M. pallidulus* (Neumann, 1912) and *Menopon gallinae* (Linnaeus, 1758), and eight ischnoceran species- *Cuclotogaster heterographus* (Nitzsch, 1866), *Goniocotes gallinae* (De Geer, 1778), *Goniodes dissimilis* (Denny, 1842), *Goniodes gigas*

(Taschenberg, 1879), *Lagopoecus sinensis* (Sugimoto, 1930), *Lipeurus caponis* (Linnaeus, 1758), *Lipeurus tropicalis* (Peters, 1931) and *Oxylipeurus dentatus* (Sugimoto, 1934). Most of these are cosmopolitan, and apparently, highly adaptive for various geographic regions and climatic conditions. Individual birds can be parasitized by multiple species, each of which often occupies a preferred host site [13].

2.1. *Menopon gallinae* Linnaeus (Feather-shaft Louse)

Louse *Menopon gallinae*, *M. pallidum* and *M. trionocephalus* are referred to as the shaft louse, and are the most common lice species found in backyard and free range chickens. Their eggs are found cemented individually at the base of the feather shaft or along the feather barb in the breast and thigh regions. These are commonly found on domesticated chickens and guinea fowl. Their common name, the shaft louse, is given due to their habit of resting on feather shafts when undisturbed. When disturbed, lice of these species will quickly run onto the body to avoid the threat. The shaft louse is rather small (1.5 to 2.0 mm long), and feeds mainly on skin and feather debris, but may also suck blood from the wounds it produces. It prefers the chest, the shoulders and the back of birds. Eggs are whitish and laid often in clusters at the base of the feathers [14].

This louse is flat, yellow, fast moving, usually seen around the vent or under the wings, but they move quickly out of the light as feathers are parted. This also has its entire life cycle on the bird and is host specific, i.e., it would not bite humans, and feeds on the skin and feather debris. It is not life-threatening, but is an irritant and a heavy infestation can affect the performance of the birds when mating. This is mainly due to the clusters of eggs, looking like granulated sugar, which are laid at the base of the feathers under the tail. Dusting with louse powder will control the louse and it needs to pull out any feathers with eggs and then dispose of the feathers and eggs safely, because if just chuck them on the ground they will hatch and jump onto the next passing chicken. A heavy infestation can affect egg laying and make the hens to appear listless [15].

2.2. *Campanulotes* or *Goniocotes bidentatus* Burmeister (Small Pigeon Louse)

The small pigeon louse (*Campanulotes* or *Goniocotes bidentatus*), inhabits feathers of both young and old pigeons. Another species slender pigeon louse (*Columbicola columbae*, Linnaeus), is much like to the small pigeon louse and measures 2.0 to 2.8 mm long. It can be found all over the body, especially at the inner side of the wing feathers and

feeds on feather debris. Eggs are laid preferentially on the small feathers under the wings.

2.3. *Cuclotogaster heterographus* Nitzsch (Head Louse)

The chicken head louse (*Cuclotogaster heterographus*), is found about the head of chickens and peafowl. The *C. heterographus*, otherwise known as the poultry head louse, infests chickens on the skin and feathers of their head; sometimes extending onto the neck. It feeds on barbules of feathers by cutting the barbules into short pieces and using its front legs to manipulate the bits through the mandibles. Females of *C. heterographus* attach their eggs to the bases of downy feathers. Eggs hatch after 5-7 days, each nymphal instar lasts for 6-14 days and average generation time is 35 days. The head louse is about 2.5 mm long and found mainly on the head and the neck of birds. It prefers to stay close to the skin or at the base of the feathers. It does not suck blood, but feeds on skin and feather debris. It is more frequent on young birds and turkeys. Heavy infested birds may even die before maturity that severely irritates the birds around the neck and head area. They are particularly irritating to young turkeys and chicks [16].

2.4. *Goniocotes gallinae* De Geer (Fluff Louse)

Fluff louse (*Goniocotes gallinae*) prefers its operating in the fluff and under the vent and is about 1.5 millimeters long. The fluff louse is one of the smallest lice of poultry and is only 0.8 to 1.5 mm long. It is found all over the birds' body, but less densely on the head and the wings, on the fluff or base of the feathers. It also feeds mainly on feather debris.

2.5. *Goniodes gigas* Taschenberg (Large Chicken Louse)

Large chicken louse (*Goniodes gigas*) is a comparatively large louse and measure about more than 2.5 millimetres long.

2.6. *Goniodes dissimilis* Denny (Brown Chicken Louse)

The lice *Goniodes dissimilis*, *G. gigas*, *G. hologaster* and *G. abdominalis* are referred to as the brown chicken louse. These lice are medium-size louse of about 2.5 millimeters long.

2.7. *Menacanthus cornutus* (the "Other" Body Louse)

The body lice are *Eomenacanthus stramineus* (= *Menacanthus stramineus* Nitzsch), *M. ornutus*, *M. zumpti* and *M. pallidulus* species. These referred to as the body lice are one of the most common lice species found in backyard

and free range living chickens. They are most prevalent around the sparsely feathered vent, breast and thigh regions of the bird. Their eggs are found cemented in clusters to the base of the feathers, especially around the vent. The chicken body louse is the most common species on domestic birds and probably the most damaging one. The chicken body louse (*Menacanthus stramineus*) is found near the vent of a variety of domestic fowl, including chickens, peafowl, guinea fowl, quail, pheasant, ducks and geese. It is rather large (2.5 to 3.5 mm long) and of a brownish color. It feeds mainly on feather debris, but is capable of sucking blood. It lives mostly on the skin of birds, seldom on the feathers and prefers body parts with few feathers, e.g., around the vent, although in case of heavy infestations it may be found also on the head, under the wings and on the chest. The eggs are laid in clusters on the feathers or directly on the kin. The body louse *M. stramineus*, is the louse most likely to infest backyard flock. The body louse thrives on the warmth and moisture of chicken's vent, but also can be found on the breasts and thighs. It is an ecto-parasite of domesticated chickens and turkeys and the most common louse found on poultry worldwide. Eggs hatch in 4-5 days with a 14-day period required for maturation from nymph to adult. Adult females can deposit approximately 1.5 eggs per day for 12.5 days [17].

2.8. *Uchida pallidula* Morice (Small Body Louse)

It has been reported from *Phasianus colchicus* L., (Galliformes: Phasianidae) under the synonym name of *Uchida pallidula* and its type host includes *Gallus gallus* (Linnaeus) red jungle fowl (domestic chicken).

2.9. *Lipeurus caponis* Linnaeus (Wing Louse)

The lice *Lipeurus caponis*, *L. tropicalis* and *L. variabilis* are known as the wing louse. They have a long and slender body form and escape from host preening by inserting themselves between the barbs of the chicken's wing feathers. The wing louse, is 2.0 to 2.5 mm long and has a grayish color. It prefers the barbules of the wing feathers and is found mainly in the inner part of wing, tail and head feathers. It only feeds on parts of the feathers, but so intensively that is also called the depluming louse. Eggs of the wing louse *L. caponis* hatch in 4-7 days after the female has cemented these to the base of a feather. Nymphal stages of this species each last for 5-18 days, generation time typically is 18-27 days and females can live up to 36 days [18].

2.10. *Oxylipeurus dentatus* Sugimoto (Toothed Louse)

Lice *Oxylipeurus dentatus*, *O. denticlypeus* and *O. angularis* are referred to as the toothed louse. Adult lice are rather

small insects (1.5 to 3.5 mm), and found mainly in and around the feathers, especially at their base and on the body surface. They have strong chewing mouthparts, and feed on feather and skin debris as well as on body exudates. Some species may even feed on blood that comes out of the wounds they produce.

Lice are obligate parasites that spend their whole life on the hosts; they do not survive off the birds longer than a few days. They are hemimetabolic, i.e., they undergo an incomplete metamorphosis. Adult females lay eggs (nits) at the base of the feathers shafts. Each female lays up to a few hundred eggs during her lifetime, depending on the species. Eggs are visible to the naked eye as whitish masses, frequently at the base of the feathers. Larvae hatch in 4 to 7 days after egg deposition, and develop progressively to nymphs and adults. The lifecycle takes 3 to 5 weeks to complete, depending on the species. Lice live for various months, but off the host they would not survive more than a week. Since temperature and humidity remain quite constant on the body surface of the birds, lice populations are not very susceptible to seasonal changes in climatic and ecological conditions, especially indoors. Body chicken lice can be found by parting a bird's feathers and looking for egg clusters near the base of the feather. Slightly smaller than body lice, the shaft lice can lay individual eggs along the feather shaft or feather barb. All these types of lice are tiny, but can be easily identifiable when examining of birds. Chicken body lice, fluff lice and shaft lice are found primarily on the body (back, breast, vent region) of chickens. The chicken head louse prefers the crown of the head of chickens, while wing lice are found between the feather barbs on the primary or secondary wing feathers. Little is known about the life cycles of the shaft, fluff or chicken head lice, but development is probably similar to the chicken body louse *M. stramineus*. For the chicken body louse, eggs hatch in 4-5 days, with three immature (nymph) stages each taking 3-4 days between molts to the next life stage. Adult females can lay up to 4 eggs per day, averaging 1-2 eggs per day for the duration of their adult life of about 12 days. Eggs of the wing louse hatch in 4-7 days, with the entire life cycle taking 18-27 days to complete, a bit longer than other. Transmission of lice is by contact between birds, typically from hens to chicks. Therefore, spreading of lice within a bird flock is mainly driven by crowding that favors close contacts [19, 20].

Many different types of lice live on poultry and remain on the bird throughout their entire life. Eggs (nits) are laid in clusters at the base of the feather shaft and hatch in 4-7 days. An adult louse lives for about 3 weeks, laying between 50-300 eggs. The chicken body louse *M. stramineus* is usually 1-3 mm in length, yellow in colour and flat in appearance. It has a life cycle of around 3 weeks, laying eggs, which pass

through three nymph stages before becoming adult. This louse is commonly found around the vent area and under the wings. Lice may live for several months on the host, but only remain alive for roughly a week off the host. Chickens are less commonly infested with *M. gallinae* (on feather shafts), *L. caponis* (mainly on the wing feathers), *C. heterographus* (mainly on the head and neck), *G. gallinae* (in the fluff), *G. gigas* (the large chicken louse), *G. dissimilis* (the brown chicken louse), *M. cornutus* (the body louse), *U. pallidula* (the small body louse) or *O. dentatus* (wing louse). Louse eggs are white and are laid at the feather root. Physical removal of the eggs is difficult without actually removing feathers. Lice feed by biting through the skin and ingesting serum ooze and skin debris. Infestation is more likely during autumn and winter months. Direct bird to bird contact is the usual method of transfer. People and other mammals may harbor avian lice, but only temporarily [21].

The chicken body louse (*M. stramineus*) and the shaft louse (*M. gallinae*) are the two species of lice most commonly found on poultry. Lice lay their eggs on the bird feathers, typically near the base of the feather shaft. The eggs are cemented together and so have the appearance of a collection of white particles. After hatching, lice may live on a bird for several months; however, they can survive off the bird for only one week. The entire life cycle of the lice occurs on the host bird, primarily in the feathers [22].

Depending on its species, a louse can range in length between four-hundredths of an inch (the fluff louse) to one-quarter of an inch (the large chicken louse). Poultry lice range in color from clear yellow to golden straw to dull brown; their nits or eggs, are laid in white clusters. Once laid, poultry lice nits hatch in about four to five days. The young spend approximately 9 to 12 days as nymphs (the immature life stage), molting three times before they become full adults. An adult louse lives approximately 12 days, during which an adult female lays an average of one to two eggs per day. Poultry lice are ectoparasites, parasites that live on the surface of their host's body; a louse will usually live its entire life on one host. They are attracted to the warmth and odor of their host, and can only survive on chickens and their relatives. Lice survive by eating of feather parts, dead skin, blood, or sebaceous secretions of the animal. Chickens are normally relatively effective at keeping lice and other ectoparasites off of their bodies. They accomplish this through dustbathing and preening (grooming) of their feathers daily. However, without an appropriate area to dustbathe or reduced ability to preen (such as birds with beak deformities, those with trimmed or injured beaks and injured or sick birds) by birds, lice infestations are more likely to become an issue. Molting also greatly reduces louse populations, however, molted feathers should be promptly

removed. Lice are more of a problem for chickens living in humid regions of the sphere than those living in arid regions. This is because lice are profoundly affected by variations in temperature and humidity near the host skin, which is a function of ambient humidity for birds. Concentrate on the feathers in the vent, breast and thigh regions to look for egg clusters or feeding adult louse at the base of the feathers to know if chickens have lice [23].

Lice are repelled by light and if chickens spread the feathers, they will usually scatter and hide. Adult lice are large enough to be visible to the naked eye and they are roughly the size of a sesame seed. Their eggs are found cemented individually at the base of the feather shaft or along the feather barb in the breast and thigh regions. Hatched eggs will remain attached to the feathers and appear grayish and flattened in appearance. Removal of the eggs is important because they are resistant to insecticides. It can be made easier by soaking of the bird in a bath first or by coating them with a softening agent or similar product. Clinical signs are: cement-like clusters (of eggs or nits) attached to the base of feather shafts, tiny (often straw-colored) insects on skin and feathers that scatter when exposed to light, feather damage and loss, dull appearance, frequent scratching or irritation, red patchy areas of skin, pale comb and wattles (anemia), increased preening, and restlessness [24].

In order to fully discourse treatment options for the treatment of lice, it is important to make the correct diagnosis and understand the life cycle.

3. Signs and Symptoms of Lice

It may seem obvious signs that if a flock is louse or mite infected; they look to be over preening themselves. So, if birds are noticed pecking at their feathers more than usual, it is wanted to check them a bit more closely. When inspected birds, it is needed to part their feathers and look for the pests and the egg clusters. A few other early signs are to look out for feather loss, a reduction in egg production, pale wattles and combs (due to anemia from blood loss) or just an overall unhappy chicken. It is important to note that chicken mites or lice should not go untreated. Not only will these stress out to flock, but anemia, lameness or even death can occur in birds from the blood loss and stress. The louse eggs called nits firmly attach to the base of a feather shaft, found below the vent. Often, these can be confused with a slightly 'messy' bottom and it is not until taken a closer look that can recognize them. There is an uncovered area below the vent, which is typical when a hen becomes infested with lice [25].

Some other signs are 1 to 4 mm fast-moving lice at the base of the feathers, nits stuck to the feather shafts below the vent, a drop in the number of eggs laid, irritation and scratching,

over preening, feather loss, broken feathers, and red bare bottoms. Nits are very hard to remove, although with care and a little warm soapy water, they can sometimes be broken off with the fingernails bit-by-bit. If there are lots of nits, it is often easier to wait for them to hatch and kill the lice by using a powder approved for dusting on hens or by using drops of Ivermectin on the back of the neck [26].

4. Diagnosis of Lice

It is important to understand the key difference between mites and lice. The main reason is because the treatment options can be quite different. The poultry mites are pin sized and *Knemidocoptes* species mites (also written as *Cnemidocoptes*) spend their entire three-week life cycle on their bird hosts (poultry, turkeys, pheasants). The females are viviparous; that is they lay live larvae, which have developed in the body of the adult. Scaly leg mites infect legs and cause the well-known knobby scales. Other species of mites infect beak ceres in parrots and generally only know if these mites are present from examining the symptoms. There are also mites, which live off the bird and use poultry as a mobile cafeteria and suck blood during the nights, so they are not usually visible during the day time. Generally, lice are easily visible and live on the bird in a number of locations depending on the species. Lice only have a life cycle on the bird and can be found easily. They lay eggs on the bird and these leave telltale signs present as fans of eggs (nits) on the base of the feather shafts. Eggs hatch within a few days and the eggs are usually visible in chronic infections as fans of eggs, particularly under the wing. Lice are light sensitive and scurry away when the feathers are parted. Young lice are pin head size and white, while adult lice are usually brown in color. Areas to look for lice are under the wing, around the parsons nose, around the feathers and below the cloaca. There is no part of the life cycle away from the birds and they do not tend to live in the environment for a long time. Microscopy of tape preparation or plucked hair demonstrates the parasite or the ova (nits) [27].

The infection can be confirmed by soaking off an infected scale and having this examined by a laboratory. The base of the scale needs to be carefully removed, as this is where the lab will find the mites. However, usually diagnosis on symptoms is very reliable. It is important to not confuse the swelling from leg mites than that of bumble foot, which is a larger area swelling, usually of the foot pad. Birds, which have hatched naturally under infected parents may be more likely to be infected during this time. Infected flocks where there are always multi-aged birds are likely to remain infected. The point here is always to check at least 10 birds in a flock before declaring the birds louse free [28].

5. Damage by Lice

Although lice are not life-threatening, infestations can lead to loss of condition, discomfort and skin irritation. All lice mentioned feed on feather structures; however, the chicken body louse and shaft louse are also able to feed on host tissue and blood by gnawing on skin or pinfeathers. Lice cause irritation, feather loss and decrease feather insulation and at high infestations can reduce the egg production of infested birds. These effects are pronounced in young birds [29].

Lice are generally species specific and will not readily move between animal species. When louse infestations are high on chickens, lice will occasionally crawl onto human handlers of infested birds, but the lice cannot feed and will not survive on people or in the environment off-host for long period. Symptoms of chickens with lice are similar to those with mite infestation, so make sure breeders are dealing with the right parasite. Chickens with lice may go off their feed, lose weight, reduce egg laying, experience feather loss and generally look unthrifty. The parasites might cause some birds to start scratching. Chicken lice feast on feathers, scales of dry skin and any sores on the bird. Unlike other types of lice, they do not actually suck the chicken's blood *per se*, only feeding on blood from lesions the bird acquires by other means. It can be also noticed the lice eggs, or nits, attached to the lower end of the bird's feathers [30].

Chickens are mainly infested with biting lice and these can irritate chickens and as a result they do not grow well and produce fewer eggs. Biting lice spend their entire lives on chickens, and can be found on the skin around the vent and on the breast and thighs. They primarily feed on skin and feathers of host. Lice that infect poultry do not suck blood; instead, they feed on dry skin scales, feathers and scabs. They will, however, feed on any blood that appears on the skin surface. Infested birds may appear agitated because of the skin irritation. They will have damaged feathers and appear to be in general poor health. Infested flocks may also show reduced feed intake, slowed body growth, decreased fertility, and declining egg production. Young birds are usually more seriously affected than are adult birds [31].

Chickens will keep the number of lice down they are carrying with dust baths and preening. Diatomaceous Earth can be added to the dust bath, which will be helpful, although make sure it is not too dusty because chickens are prone to respiratory problems. Diatomaceous earth, the fossilized remains of ancient plants, contains sharp edges that pierce the bodies of lice. Inspect ex-battery hens that have their beaks trimmed (de-beaked) regularly, since they cannot preen themselves very well, so are more likely to become infested with lice. Check newcomers to the flock and dust them with a louse powder as a precaution before introducing to farm [32].

6. Integrated Pest Management

An Integrated Pest Management (IPM) combines different types of controls from hands-on pest removal to traditional synthetic pesticides in a sensible, long-term plan [33-46]. Poultry integrated pest management is based on pest identification, pest population monitoring, and methods of cultural, biological and chemical control. Monitoring of birds should be manually done by inspecting for lice periodically. The breast, back, vent region, under wings, head and wings of birds should be examined. The best way to spot wing lice is by holding the wings out and up, so that the primary feathers are back-lit. Also look for clumps of eggs at the base of feathers in addition to active louse populations. The exact louse species can be approximated by where they are found, though it is especially difficult to distinguish body-dwelling lice without specialized training. Louse numbers can be estimated per bird, but this can be difficult and requires practice, as the lice will be constantly moving when feathers are parted. Even though lice cause economic damage to birds, it is generally much less severe than infestations of blood-feeding mites (*Ornithonyssus* or *Dermanyssus*) and no economic thresholds for lice have been determined [47].

If unable to check all birds in a flock, focus energy on young and old birds, birds that look ill (drooping head, lack of energy) or birds with trimmed or damaged beaks. Populations of the louse are kept in check by host grooming and birds with trimmed or damaged beaks will harbor higher numbers of lice. Beak intact birds may harbor less than 50 lice per bird compared to hundreds of lice per bird on beak trimmed individuals [48].

6.1. Prevention of Lice

The first priority to avoid outbreaks of lice on poultry houses is to prevent the introduction of lice from outside, since wild birds can transmit most lice species. The second measure is to prevent dissemination of lice between poultry houses, if one of them becomes infested. Nests of wild birds in or around the facilities should have to be destroyed. Whatever equipment or hardware is moved between poultry houses (cages, baskets, crates, boxes, trays, etc.), it has to be disinfected before being introduced into a louse-free building. Keep the coop and run clean, prevent overcrowding in flock, inspect chickens at least every 1-2 weeks for the presence of lice, quarantine and inspect any new birds that are adding to flock for at least 2 weeks, and prevent wild birds from nesting in or near to coop and run [49].

Prevent lice populations from becoming problematic in flock by thoroughly examining of new birds and equipment before bringing them onto property. Pyrethrin-based insecticides are

commonly available for chemical control of lice in the form of on-animal sprays, powders or dusts. Be aware that multiple applications may be required to control all lice and some products will not affect eggs. Diatomaceous earth can be used to achieve louse control, and a safe and effective way to apply is to mix it with sand and allow the birds to dustbathe in the mixture. For this purpose, mix 6 cups of food grade DE with 25 lbs ($\frac{1}{2}$ bag) washed play sand in a plastic container (swimming pool or concrete mixing bin). When birds dustbathe in the mixture, the DE gets into the feathers and onto the skin where the lice live, causing the lice to dry out and die. Even if some birds do not dustbathe, the presence of a portion of the flock dustbathing can help to manage overall ectoparasite populations. Add food grade diatomaceous earth to coop and nesting box bedding. Add it to the dust bathing areas too to kill lice on chickens directly [50].

6.2. Treatment of Lice on Chickens

While there are plenty of methods to prevent chicken lice on flock, once there have an infestation, it needs to treat birds to avoid further spread. Poultry lice lay their eggs on the host bird's feathers, especially near to the base of the feather shaft, which she cements to the feather shaft. Eggs are white and commonly appear in bunches on the lower feather shaft. Feathers of infested birds may have a moth-eaten appearance. Due to the feather damage, the bird may have a dull or roughened appearance. The cottony areas at the base of the quill are the egg sacs. These can be so large and numerous that they irritate the skin and ruin the hen's feathers to the point that even preening cannot remove them. In that case, owner might want to bathe hen that will make her life more comfortable. Chickens, although they do not like to wade in water, surprisingly do like this spa (bath) treatment [51].

There are several species of lice that affect poultry and multiple species can affect a bird at any given time. Some species can be localized on specific locations like the quill lice or others can be found over most of the body surface like the chicken body lice. The lice found on poultry do not suck blood as the lice found in other species of animals; rather they feed on dry skin scales, feathers and scabs. However, they will ingest blood extruding from irritated skin. The entire life cycle of the lice occurs on the host bird, primarily in the feathers. Poultry lice are host specific and cannot be transferred to humans. Inspect the ventral region of the bird for live lice crawling on the bird and for nits (lice eggs) as most infestations start in this area of the bird's body. The entire life cycle of these pests occurs on the fowl, which makes them fairly easy to control, since they do not live in dirt and wood or in intermediary hosts like beetle larvae. Lice can live only a couple of days off of their host, so even in the

worst infestations, a thorough coop cleaning and ridding them from the birds, will take care of the problem [52].

A hen's first line of defense against lice is to dust bathe. This is when a hen finds a wallow of loose, warm dirt, lies down in it, kicks it about and gets it under her feathers. The dirt kills off the soft-bodied lice by both desiccating and shredding them. In the winter when the ground is frozen and during times of mud and cold, hens cannot dust bathe outside, so the louse population explodes. One remedy to this situation is by half-filling of an inexpensive kitty litter tub with coarse builder's sand and then adding a cup of food grade diatomaceous earth to the mix. Food-grade diatomaceous earth derived from microscopically small water creature diatoms is jagged and lacerates the lice to kill off the lice. Be sure to only use food-grade DE as Agricultural DE, used to kill slugs, etc., derived from sea diatoms, is very sharp and it will shred chicken's soft tissues if ingested [53].

One new generation powder uses is elemental sulphur and rhizome un-extracted essential oil combination. Research has shown this to be highly effective in killing of over 95% of lice within 48 hours when applied thoroughly to a heavily infested bird. It is safe to use on birds of all ages, there are no known impacts from residues, a repeat application is really important and they are not detrimental to the bird. Liquid louse sprays often contain insecticides (malathion) or extracted or distilled essential oils. Some essential oils can be caustic to skin when used at concentrations, which inhibit the lice. The oils usually purchased as a concentrate and carriers can be severe on nostrils and eyes. They can also only be louse repellents, and the lice use the relocation principle and return quickly. Never use sprays when wet birds can be easily chilled post treatment as this will trigger respiratory diseases, which are far worse than lice infections. Ivermectin is by far the easiest way to remove lice on chickens and it also kills most common poultry worms, and has a residual effect once applied [54].

For control of lice, owners have to treat the birds directly as treating of the only environment does not work. Permethrin, natural pyrethrum and carbaryl dust are effective insecticides for lice, but must consult to a veterinarian for the correct way to use them on chickens. Dust each flock member with DE or a garden dust such as Sevin-5%. As there are alternatives, other method prior to using Sevin dust is Permethrin (there is an egg with drawl period with its use). Thoroughly clean entire coop, and run and add food grade diatomaceous earth to all the bedding. In addition to applying these dusts within the coop, treat individual birds by putting of the powder in a trash bag, then placing the chicken inside with the exception of the head. Shake the bag with the chicken enclosed for thorough coating. Dust is also available in a can and owner can shake the powder onto the bird rather than use the bag

method. Repeat the treatment for nit removal two weeks later. For severe infestations, veterinarian can apply the dewormer ivermectin to birds [55].

6.3. Natural Recipe

The problem is that most treatments use harmful chemicals, which are not good for humans, birds or the environment. If anyone does not like the idea of using pesticides on flock, pursue natural ways to get rid of or prevent lice. Provide to chickens with food-grade diatomaceous earth for their dust baths. A recipe for lice removal is offered, consisting of the following ingredients mixed in a tub; 2 cups of salt, 2 cups of distilled white vinegar, 2 cups of gentle liquid soap and 5 gallons of warm water. Place each chicken in flock into the tub for five minutes, with only the head protruding. Rinse the chicken in warm water after the bath and dry the bird thoroughly with a towel. Repeat the bath two weeks later and this second bath eradicates the nits.

The adage of garlic cures everything, but may not necessarily be accurate, however it can help in several ways in battle against chicken lice. Putting of garlic or garlic juice in chicken's diet can be helpful since most of the parasites do not like the taste of it in the chicken's blood. It can also be created a mix of water, garlic juice and a type of essential oil (like lavender), and spray it directly on chickens and around their coop.

Plant-borne insecticides have been evaluated against Mallophaga, wherein tested products mainly contained bioactive principles from two Meliaceae, *Azadirachta indica* and *Carapa guianensis* [56-61]. Good control of infestations without using of natural lousicides has been achieved with thuringiensin; the exotoxine of *Bacillus thuringiensis*, directly applied on infested birds, and the most effective to Mallophaga are *B. thuringiensis* var. *kurstaki*, *kenyae* and *morrisoni*. However, commercial products with thuringiensin may not be available everywhere for use on poultry, although they are quite common in agriculture [62].

Practicing of good biosecurity is essential to make sure that chickens stay happy and healthy. Taking precautionary measures similar to what mentioned above will also help to prevent mites or lice infestations in the future. While infestations can occur anywhere and anytime, always receive new happy and healthy chickens from reputable breeders free of common chicken parasites.

Chickens can be infested with several different kinds of lice and the most common being: head louse, body louse, shaft louse and wing louse. The chicken body louse is the most common. Others can be found occasionally, but are seldom found in significant numbers. These minor lice species have basically the same biology and habits as the chicken body

louse, and the same control strategies control them. All lice on birds are chewing lice and none of those suck blood. They constantly irritate the birds with their claws and mouthparts as they crawl over the bodies of the birds. Lice seldom leave the bodies of infested birds except to move towards other birds.

Body lice may build up huge populations on birds. Large infestations can cause loss of body weight and a significant drop in egg production. The entire life cycle can occur in as little as 3 weeks. Lice eggs are laid in masses and stick to the base of feathers. When examining of birds for lice, examine the whole body, because lice do not circle around the vent as northern fowl mites do. The adult lice are large (one-eighth inch long) and yellow. The white egg masses at the base of the feathers are the best indicators of a lice infestation. Like northern fowl mites, lice populations build up in cooler weather. As with northern fowl mites, consider the time of year and age of the flock when making control plans [63].

The most common way chickens catch lice is through wild birds and by adding of new birds to an existing flock without quarantine or from contaminated clothing or equipment. To treat chickens use a poultry dust and make sure to focus on the wings, saddle feathers and main tail area. In 14 days repeat the dusting and then check again for a further 14 days later. Owners should find after the second check that all the lice are gone, if they are not, dust them again and wait a further 14 days.

The Amblycera and Ischnocera can act as vectors of Eulimdana species (Nematoda: Filarioidea) in charadriiform birds. Besides the ability of Mallophaga to vector filarial worms, the live and virulent *Pasteurella multocida*, the agent of avian or fowl cholera, is found in the gut of *M. stramineus* and *M. gallinae* fed on the blood of hens [64]. Insecticides that treat northern fowl mites will also control lice. Generally, lice do not leave the host bird unless they are moving to another bird, so careful treating of the birds' environment is not as crucial as it is with the other external parasites. Nevertheless, it is important to treat the environment, since the time from egg to adult for lice is about three weeks, so repeated treatments are required by using of pesticides [65-74].

7. Conclusion

Poultry production plays an important role in the socioeconomic development of any country. Lice are not life-threatening (unlike mites), but their regular monitoring on poultry is needed. As the incidence of backyard chickens being presented in practice increases, it is important that veterinary nurses can identify the commonly found poultry pests and know how best to advice owners on treatment and

prevention. Given that this parasite is quite easy to eliminate or reduce to low levels, they should be difficult to find in any well managed flock. Untreated parasites (both external and internal) can result in debilitation and in some cases can cause death. Chickens will keep the number of lice they are carrying down with dust baths and preening. Diatomaceous earth can be added to the dust bath, which will be helpful, although make sure it is not too dusty because chickens are prone to respiratory problems. Inspect ex-battery hens that have had their beaks trimmed (de-beaked) regularly, since they cannot preen themselves very well so are more likely to become infested with lice. Avoid contact with other birds that have lice and check newcomers to the flock, and dust them down with a louse powder as a precaution before introducing to them. Efficient louse management and control is an important factor in all ectoparasite programs.

Lice remain always on the birds, consequently, chemical control with whatever lousicides has to be directly administered to the birds and not to the facilities or the environment of the birds. Most common lousicide application is by spraying (hand or power spray) the birds directly. Dipping of bird is less frequent, but will work as well. Dusting also works and it allows treating of the birds indirectly, e.g., applying the insecticidal powder to the bedding and letting the birds dust themselves. However, roosters and cocks do not dust themselves like hens and it may be necessary to treat them separately. Laying hens have to be treated directly. Pyrethrum-based louse powders can be used every 4 days for 2 weeks in autumn or winter. Eggs are not killed during treatment, so repeated treatment is essential to catch the emerging nymph stage of the life cycle. Most synthetic lousicides belong to the organophosphates, carbamates and pyrethroids and are usually available as concentrates to be diluted before use. Care must be taken particularly with some organophosphates that may be toxic to birds if slightly overdosed. Macrocyclic lactones (e.g., ivermectin) either as feed additives or as tablets are available for poultry in a few countries, mainly for fighting cocks. However, at the therapeutic dose they are unlikely to control poultry lice. In most countries, they are not approved for poultry at all, neither for layers nor for broilers, due to excessive residues in eggs and meat. For the time being there are no vaccines that will protect poultry by making them immune to lice. There are no repellents, natural or synthetic that will keep lice away from poultry. And there are no traps for catching of poultry lice, for the simple reason that they spend their whole life on the animals and therefore there are no stages in the environment searching or waiting for a host. So far, there are no effective biological control methods against poultry lice. Diatomaceous earth powder can be used for on-going control on birds and in housing, avoid stress or

overcrowding and allow birds access to dust baths with louse powder is recommended.

References

- [1] Sarwar, M. 2015. Insect Borne Diseases Transmitted by Some Important Vectors of Class Insecta Hurling Public Health. *International Journal of Bioinformatics and Biomedical Engineering*, 1 (3): 311-317.
- [2] Sarwar, M. 2015. Direct Possessions of Insect Arthropods on Humans Owing to Allergen, Bloodsucking, Biting, and Stinging Side By Side Case Diagnosis and Treating. *International Journal of Bioinformatics and Biomedical Engineering*, 1 (3): 331-337.
- [3] Sarwar, M. 2015. Dissemination of Infectious Agents of Human Diseases via Insects Vectors of Public Health Prominence. *American Journal of Clinical Neurology and Neurosurgery*, 1 (3): 169-174.
- [4] Sarwar, M. 2015. Insects Effecting by Annoyance to Peoples Relating to the Public Health Concerns. *American Journal of Clinical Neurology and Neurosurgery*, 1 (3): 175-181.
- [5] Price, R. D., Hellenenthal, R. A., Palma, R. L., Johnson, K. P. and Clayton, D. H. 2003. The chewing lice: world checklist and biological overview. *Illinois natural history survey special publication* 24. 501 pp.
- [6] Palma, R. L. and Jensen, J. K. 2005. Lice (Insecta: Phthiraptera) and their host associations in the Faroe Islands. *Steenstrupia*, 29 (1): 49-73.
- [7] Young, F. N. and Kritsky, G. 2002. *The Hemipteroidea. A Survey of Entomology* (2nd ed). iUniverse. pp. 178-191.
- [8] Prelezov, P. N., Groseva, N. I., Goundasheva and D. I. 2006. Pathomorphological changes in the tissues of chickens, experimentally infected with biting lice (Insecta: Phthiraptera). *Vet. Arhiv.*, 76: 207-215.
- [9] Sarwar, M. and Rauf, A. 2018. Ectoparasitic Insects Genera of Veterinary Importance and Some Aspects of Their Control. *American Journal of Economics, Finance and Management*, 4 (4): 116-123.
- [10] Wall, R. and Shearer, D. 2001. *Veterinary ectoparasites: biology*. In: *Pathology and Control* (second ed.). Blackwell Science, London. 304 pp.
- [11] Sychra, O. 2005. Chewing lice (Phthiraptera: Amblycera, Ischnocera) from chukars (*Alectoris chukar*) from a pheasant farm in Jinachovice (Czech Republic). *Vet. Med. Czech.*, 50: 213-218.
- [12] Clayton, D. H., Adams, R. J. and Bush, S. E. 2008. Phthiraptera, the chewing lice. pp. 515-526. In: Atkinson, C. T., Thomas, N. J. & Hunter, D. B. (Eds.), *Parasitic diseases of wild birds*. Ames, Iowa: Wiley-Blackwell. 595 pp.
- [13] Fabiyi, J. P. 1996. Association between duration of humid season and geographical distribution patterns of different species of chewing lice (Mallophaga: Insecta) infesting domestic chickens in Nigeria. *J. Parasitol.*, 82: 1034-1036.
- [14] Prelezov, P. N. and Koinarski, V. T. 2006. Species variety and population structure of Mallophaga (Insecta: Phthiraptera) on chickens in the region of Stara Zagora. *Bulg. J. Vet. Med.*, 9: 193-200.

- [15] Portugaliza, H. P. and Bagot, M. A. 2015. Different species of lice (Phthiraptera), fleas (Siphonaptera) and ticks (Ixodida) collected from livestock, poultry, reptile and companion animal in Leyte Island, Philippines. *Livestock Research for Rural Development*, 27 (8): Article #151.
- [16] Galloway, T. D. and Lamb, R. J. 2015. Seasonal population dynamics of four species of chewing lice (Phthiraptera: Menoponidae, Philopteridae) on feral pigeons (Aves: Columbiformes: Columbidae). *The Canadian Entomologist*, 147: 712-722.
- [17] Stockdale, H. J. and Raun, E. S. 1965. Biology of the chicken body louse, *Menacanthus stramineus*. *Annals of the Entomological Society of America*, 58 (6): 802-805.
- [18] Page, R. D. M., Clayton, DH, Paterson, AM. 1996. Lice and cospeciation: a response to Barker. *International Journal for Parasitology*, 26: 213-218.
- [19] Bay, D. E. and Harris, R. L. 1988. *Introduction to Veterinary Entomology (A Guide to Livestock Insects)* 2nd edition. Stonefly Publisher. 111 pp.
- [20] Trivedi, M. C., Rawat, B. S. and Saxena, A. K. 1991. The distribution of lice (Phthiraptera) on poultry (*Gallus domesticus*). *International Journal for Parasitology*, 21 (2): 247-249.
- [21] Murillo, A. and Mullens, B. 2016. Diversity and Prevalence of Ectoparasites on Backyard Chicken Flocks in California. *Journal of Medical Entomology*, 53 (3): 707-711.
- [22] Rekasi, J., Rozsa, L. and Kiss, B. J. 1997. Patterns in the distribution of avian lice (Phthiraptera: Amblycera, Ischnocera). *Journal of Avian Biology*, 28: 150-156.
- [23] Durden, L. A. and Musser, G. G. 1994. The sucking lice (Insecta: Anoplura) of the world: a taxonomic checklist with records of mammalian hosts and geographical distributions. *Bulletin of the American Museum of Natural History*, 218: 1-90.
- [24] Rozsa, L., Rekasi, J. and Reiczigel, J. 1996. Relationship of host coloniality to the population ecology of avian lice (Insecta: Phthiraptera). *Journal of Animal Ecology*, 65: 242-248.
- [25] Marshall, I. K. 2003. A morphological phylogeny for four families of amblyceran lice (Phthiraptera: Amblycera: Menoponidae, Boopidae, Laemobothriidae, Ricinidae). *Zoological Journal of the Linnean Society*, 138 (1): 39-82.
- [26] Bowman, D. D. 2009. *Georgis' Parasitology for Veterinarians* (9th ed). Saunders Elsevier, USA.
- [27] Sychra, O., Harmat, P. and Literak, I. 2008. Chewing lice (Phthiraptera) on chickens (*Gallus gallus*) from small backyard flocks in the eastern part of the Czech Republic. *Veterinary Parasitology*, 152: 344-348.
- [28] Clayton, D. H. and Drown, D. M. 2001. Critical evaluation of five methods for quantifying chewing lice (Insecta: Phthiraptera). *J. Parasitol.*, 87: 1291-1300.
- [29] Abivardi, C. 2001. Destructive and useful insects. *Iranian Entomology: an Introduction*. Springer. pp. 563-902.
- [30] Durden, L. A. and Musser, G. G. 1994. The mammalian hosts of the sucking lice (Anoplura) of the world: A host-parasite list. *Bulletin of the Society for Vector Ecology*, 19 (2): 130-168.
- [31] Kellogg, V. L. 1896. New Mallophaga, II, from land birds; together with an account of the mallophagous mouth-parts. *Proceedings of the Californian Academy of Science*, 2nd Series, 6: 431-548.
- [32] Urquhart, G. M., Armour, J., Duncan, J. L., Dunn, A. M., Jennings, F. W., 1987. *Veterinary Parasitology*. Longman Scientific and Technical, UK, pp. 165-166.
- [33] Sarwar, M. 2004. Concept of integrated insect pests management. *Pakistan & Gulf Economists*, 23 (46 & 47): 39-41.
- [34] Sarwar, M. 2015. Insect Vectors Involving in Mechanical Transmission of Human Pathogens for Serious Diseases. *International Journal of Bioinformatics and Biomedical Engineering*, 1 (3): 300-306.
- [35] Sarwar, M. 2016. Diseases Transmitted by Blood Sucking Mites and Integrated Mite Management for Their Prevention. *American Journal of Food Science and Health*, 2 (6): 169-175.
- [36] Sarwar, M. H. and M. Sarwar. 2016. Medical Importance of Ticks Bite and Diseases Transmission by Means of It Affecting Humans. *Biomedical and Health Informatics*, 1 (2): 44-51.
- [37] Sarwar, M. 2016. Ticks (Arachnida: Acari) induced Paralysis in Humans and Control of Incidence in the Current Civilization. *International Journal for Research in Social Science and Humanities Research*, 1 (7): 27-36.
- [38] Sarwar, M. 2016. Mites (Arachnida: Acarina) Affecting Humans and Steps Taking for the Solution of Problematics. *International Journal for Research in Mechanical Engineering*, 1 (7): 1-14.
- [39] Sarwar, M. 2016. Life History of House Fly *Musca domestica* Linnaeus (Diptera: Muscidae), its Involvement in Diseases Spread and Prevention of Vector. *International Journal for Research in Applied Chemistry*, 1 (7): 23-34.
- [40] Sarwar, M. 2016. Mites- The Tiny Killers to Push Honeybee Colonies into Collapse and Integrated Pest Management. *International Journal for Research in Applied Physics*, 1 (7): 12-21.
- [41] Sarwar, M., Ayesha, N., Sarwar, M. H. and Jaweria, N. 2017. Miscellaneous Ways to Repel, Treat and Avoid Being Bitten by Sand Flies (Diptera: Psychodidae: Phlebotominae) on Human. *American Journal of Food Science and Health*, 3 (4): 64-69.
- [42] Sarwar, M., Sarwar, M. H. and Khan, M. A. 2017. Crimean Congo Hemorrhagic Fever and Its Prevention in Humans through Tick Vectors Control. *International Journal of Environmental Planning and Management*, 3 (3): 16-22.
- [43] Sarwar, M. 2017. Integrated Control of Insect Pests on Canola and Other Brassica Oilseed Crops in Pakistan. pp. 193-221. In: *Integrated Management of Insect Pests on Canola and Other Brassica Oilseed Crops*, Gadi, V. P. Reddy (Ed.). CABI, Wallingford, UK. 408 pp.
- [44] Sarwar, M. 2020. House Dust Mites: Ecology, Biology, Prevalence, Epidemiology and Elimination. In: *Parasitology and Microbiology Research*, G. A. B. Pacheco and A. A. Kamboh (Eds.). IntechOpen Ltd., London, UK. p. 26.
- [45] Sarwar, M. 2020. Typical Flies: Natural History, Lifestyle and Diversity of Diptera. In: *Life Cycle and Development of Diptera* (M. Sarwar, Editor). IntechOpen Ltd., London, UK. p. 50.

- [46] Sarwar, M. 2020. Experimental Induction of Insect Growth Regulators in Controls of Insect Vectors as well as Crops and Stored Products Pests. *Specialty Journal of Agricultural Sciences*, 6 (1): 32-41.
- [47] Axtell, R. C. 1999. Poultry Integrated Pest Management: Status and Future. *Integrated Pest Management Reviews*, 4: 53-73.
- [48] Chen, B. L., Haith, K. L. and Mullens, B. A. 2011. Beak condition drives abundance and grooming-mediated competitive asymmetry in a poultry ectoparasite community. *Parasitol.*, 138: 748-757.
- [49] Radfar, M. H., Fathi, S., Asl, E. N., Dehaghi, M. and Seghinsara, H. R. 2011. A survey of parasites of domestic pigeons (*Columba livia domestica*) in South Khorasan. *Iranian Journal of Veterinary Research*, 4 (1): 18-23.
- [50] Brooke, M. D. L. and Nakamura, H. 1998. The acquisition of host-specific feather lice by common cuckoos (*Cuculus canorus*). *Journal of Zoology*, 244 (02): 167-173.
- [51] Rozsa, L. 1997. Patterns in the abundance of avian lice (Phthiraptera: Amblycera, Ischnocera). *Journal of Avian Biology*, 28: 249-254.
- [52] Rani, N., John, L. and Basith, S. A. 2008. Prevalence of ectoparasites of chicken reared under different systems of management. *Journal of Veterinary Parasitology*, 22 (2): 93-94.
- [53] Sia, S. G., Amil, C. J. A., San, J. J. A. P., Sia, S. M. L., Maguad, G. S., Salinas R. A., Ragraio, E. M., Santiago, A. A. and Ramos, G. B. 2013. Ectoparasite Survey of Quarantined Animals in a Wildlife Rescue Center in Quezon City, Philippines. *World Journal of Agricultural Research*, 1 (3): 44-47.
- [54] Salam, S. T., Mir, M. S. and Khan, A. R. 2009. Prevalence and seasonal variation of ectoparasitic load in free range chicken of Kashmir valley. *Tropical Animal Health Production*, 41: 1371-1376.
- [55] Mullen, G. R. and Durden, L. A. 2002. *Medical and Veterinary Entomology*. Elsevier Science. 591 pp.
- [56] Sarwar, M. 2015. The Killer Chemicals for Control of Agriculture Insect Pests: The Botanical Insecticides. *International Journal of Chemical and Biomolecular Science*, 1 (3): 123-128.
- [57] Sarwar, M. 2015. Usage of Biorational Pesticides with Novel Modes of Action, Mechanism and Application in Crop Protection. *International Journal of Materials Chemistry and Physics*, 1 (2): 156-162.
- [58] Sarwar, M. 2015. Information on Activities Regarding Biochemical Pesticides: An Ecological Friendly Plant Protection against Insects. *International Journal of Engineering and Advanced Research Technology*, 1 (2): 27-31.
- [59] Sarwar, M. 2016. Usage spots of biological insecticides in consort with target insect pests or vectors and application in habitat. *International Journal of Entomology and Nematology*, 3 (1): 14-20.
- [60] Sarwar, M. 2016. A potent folklore of botanical plant materials against insect pests together with their preparations and applications. *Sky Journal of Biochemistry Research*, 5 (4): 58-62.
- [61] Sarwar, M. and M. Salman. 2015. Success Stories of Eco-friendly Organically Acceptable Insecticides as Natural Products Discovery. *International Journal of Materials Chemistry and Physics*, 1 (3): 392-398.
- [62] Benellia, G., Casellia, A., Giuseppeb, G. D. and Canale, A. 2018. Control of biting lice, Mallophaga- a review. *Acta Tropica*, 177: 211-219.
- [63] Mansur, M. K., Mahmoud, N. M., Allamoushi, S. M. and Abed-El-Aziz, M. M. 2019. Biodiversity and prevalence of chewing lice on local poultry. *Journal of Dairy, Veterinary & Animal Research*, 8 (1): 26-31.
- [64] Bartlett, C. M. 1993. Lice (Amblycera and Ischnocera) as vectors of *Eulimdana* spp. (Nematoda: filarioidea) in charadriiform birds and the necessity of short reproductive periods in adult worms. *J. Parasitol.*, 79, 85-91.
- [65] Sarwar, M. 2015. The Killer Chemicals as Controller of Agriculture Insect Pests: The Conventional Insecticides. *International Journal of Chemical and Biomolecular Science*, 1 (3): 141-147.
- [66] Sarwar, M. 2015. Commonly Available Commercial Insecticide Formulations and Their Applications in the Field. *International Journal of Materials Chemistry and Physics*, 1 (2): 116-123.
- [67] Sarwar, M. 2016. Inorganic Insecticides used in Landscape Settings and Insect Pests. *Chemistry Research Journal*, 1 (1): 50-57.
- [68] Sarwar, M. 2016. Potential Uses of Synergists in Insecticides Resistance Management Accompanied by Their Contributions as Control Agents and Research Tools. *Chemistry Research Journal*, 1 (3): 21-26.
- [69] Sarwar, M. 2016. Families of Common Synthetic Agrochemicals Designed to Target Insect Pests or Vectors in Landscapes and Households. *Chemistry Research Journal*, 1 (3): 7-13.
- [70] Sarwar, M. 2016. A Glance at Pesticides Usage: Remunerations and Complications Associated with Insecticides Putting in Practice. *International Journal of Research in Agricultural Research*, 1 (7): 10-19.
- [71] Sarwar, M. 2016. Indoor risks of pesticide uses are significantly linked to hazards of the family members. *Cogent Medicine*, 3: 1155373.
- [72] Sarwar, M. and M. Salman. 2015. The Paramount Benefits of Using Insecticides and Their Worldwide Importance in Food Production. *International Journal of Bioinformatics and Biomedical Engineering*, 1 (3): 359-365.
- [73] Sarwar, M., Shad, N. A. and Batool, R. 2020. Integrated management of vectored viral diseases of plants. In: *Applied Plant Virology: Advances, Detection, and Antiviral Strategies*, L. P. Awasthi (Ed.). Elsevier Inc., London. p. 707-724.
- [74] Noreen, A., Sarwar, M. and Babar, H. S. 2021. Biotechnological Trends in Insect Pests Control Strategy. In: *Biopesticides in Organic Farming: Recent Advances*, L. P. Awasthi (Ed.). CRC Press, Boca Raton. p. 333-339.