Annals of Parasitology 2022, 68(3), 595–603
doi: 10.17420/ap6803.466
Copyright© 2022 Polish Parasitological Society

Original paper

Mites and helminths infestation in Lebanese broiler farming systems

Houssam SHAIB, Youssef OBEID

[1]Department of Agriculture, Faculty of Agricultural and Food Sciences, American University of Beirut, Lebanon

Corresponding Author: Houssam Shaib; e-mail: hs45@aub.edu.lb

ABSTRACT. This study aims at the identification of endo- and ectoparasites in broiler farms while assessing their prevalence in semi-open and closed rearing systems in Lebanon. Seventeen semi-open and six closed broiler farms were investigated in various Lebanese provinces between March and September 2020 and 2021. Intestinal and composite litter samples were collected and observed for morphological identification of prevalent parasites. Results notably revealed the prevalence of mites in all of the surveyed farms. Moreover, mixed mite-helminth infestation was recorded in 100% of the semi-open farms and 50% of the closed ones. The northern fowl mite *Ornithonyssus sylviarum* was the predominant chicken parasitic mite in both systems. The poultry red mite *Dermanyssus gallinae*, was present in 6% of the semi-open farms and was not detected in closed farms. The mammalian itching mite *Sarcoptes scabiei* and the grain mite *Acarus siro* were also identified and had similar prevalence pattern as the red poultry mite. Eggs and/or larvae stages of one parasitic helminth species, *Ascaridia galli*, were detected in half of the semi-open and closed farms while adult worms were not present. This study documents for the first time the prevalence of specific endo- and ectoparasites in Lebanese broiler farms, reflecting managerial problems and poor biosecurity practices. Nevertheless, the identification of specific parasites in this work paves the way towards implementing proper control methods against these overlooked, yet devastating, organisms.

Keywords: broilers, rearing systems, ectoparasites, endoparasites, Lebanon

Introduction

Ectoparasites and endoparasites are problematic for the commercial poultry production in Lebanon. The ectoparasites include arthropods such as lice, mites, fleas, and ticks which are isolated from skin and feathers; while endoparasites refer to protozoa, cestodes, nematodes and trematodes which are isolated from viscera, blood, and pooled poultry droppings [1]. It is believed that parasites are more prevalent in free range and backyard poultry due to the presence of holes crevices and craks that provide shelters for parasites to hide and avoid control methods. Nevertheless, many countries suffer from avian endo- and ectoparasites infections in their commercial poultry production worldwide, including developed countries [1–5].

These parasites usually appear in poultry farms lacking good management and biosecurity measures [1,6,7]. Primarily they have the impact to minimize the productivity of poultry, which can be obviously seen in reduced feed conversion efficiency, weight gain, reproductive potential in males, egg production in females, and meat quality; they can also lead to anemia and death [6,7]. Heavy infestation with the northern fowl mite *Ornithonyssus sylviarum* affects weight gain and reproductive performance of chickens as it drains up to 6% of the bird's blood [5]. Poultry farms infestation with the red mite *Dermanyssus gallinae* results in significant economic losses of around 360 million euros in Europe alone [8]. *Ascaridia galli* reduces egg production and body weight of laying hens, while a heavy infection with this nematode increases mortality and affect the immune system by suppressing humoral immunity [9]. Moreover, they are a major contributor to disease outbreaks. As vectors, they aid in the transmission of many poultry diseases such as, but not limited to, *Salmonella enteritidis*, *Pasteurella multocida*, *Borrelia anserina*, fowlpox virus, arboviruses, Newcastle Disease virus, and possibly Chlamydia [1,5,7,10].

Table 1. Various farms investigated for endo- and ectoparasites in Lebanon

Province	Farming system	No of farms visited	Number of birds per farm	Bird age (days)	Number of tested birds	Type of samples collected
North Lebanon (Akkar)	semi-open	8	15,000–20,000	20–30	10	Litter, intestines
North Lebanon (Koura)	semi-open	6	15,000–20,000	20–30	10	Litter, intestines
Mount Lebanon (Baabda)	semi-open	3	15,000–20,000	20–30	10	Litter, intestines
Mount Lebanon (Baabda)	closed	3	15,000–20,000	10	10	Litter, intestines
Mount Lebanon (Jbeil)	closed	2	15,000–20,000	20–28	10	Litter, intestines
South Lebanon (Tyre)	closed	1	15,000–20,000	20–30	10	Litter, intestines

Beside coccidiosis, and to the best of the authors' knowledge, there are no published reports on the presence of specific ecto- and/or endoparasites in broiler farms in Lebanon where poultry production is one of the major components of the agricultural sector and provides affordable quality protein for local consumers. Therefore, and due to the significant economic and animal welfare adverse impact of these neglected parasites, the need for sustainable management and control of these organisms is vital.

This study aims at assessing the prevalence of ectoparasites and intestinal helminths in selected Lebanese broiler farms adopting closed or semi-open rearing systems and the identification of the parasites species that infect broilers in the study area based on their morphological characteristics.

This work constitutes a cornerstone of efficient programs aiming at the control of these parasites in Lebanese poultry farms.

Materials and Methods

Study area and birds

Lebanon is located in South-West Asia, between 34°42′ 33°3′ N and 35°6′ 36°37′ E with a unique physiography consisting of a narrow coastal plane and two parallel north/south mountains separated by the fertile Bekaa Valley [11]. Lebanon has mild, dry summers and cold, wet winters with the heaviest rainfall occurring between November and April. The investigated broiler farms are distributed in the South, North and Mount Lebanon regions and were surveyed during the spring and summer of 2020 and 2021. Sampling was carried out during regular farm check-up visits and based on the farmers' willingness to allow for the collection litter samples and freshly dead birds' intestines from their farms. A total of 23 broiler farms, adopting semi-open (n=17) or closed (n=6) rearing system, were included in this investigation and the average size of a flock per farm was approximately 20,000 broilers (Tab. 1). The study targeted flocks that were showing morbidity signs or having mediocre performance such as low live body weight and/or high feed conversion. Housing conditions in each farm were observed including ventilation, litter quality and implementation of biosecurity measures.

Sample collection and preparation

Composite litter samples were examined for helminths and ectoparasites. The composite samples were prepared by pooling 5 handful amounts of litter in one plastic bag. In addition, freshly dead broilers that were encountered when visiting the farm were examined for intestinal helminths. The intestines of dead birds or those showing mediocre performance were collected and transported in an ice chest to the Animal Research and Diagnostic Lab at the American University of Beirut for analysis. It is worth noting that litter and intestinal samples were analyzed 10–24 hours after collection.

Preparation of litter samples for microscopic observation

Litter samples were mixed with physiological saline (1:1 w/v) in sterile disposable conical tubes.

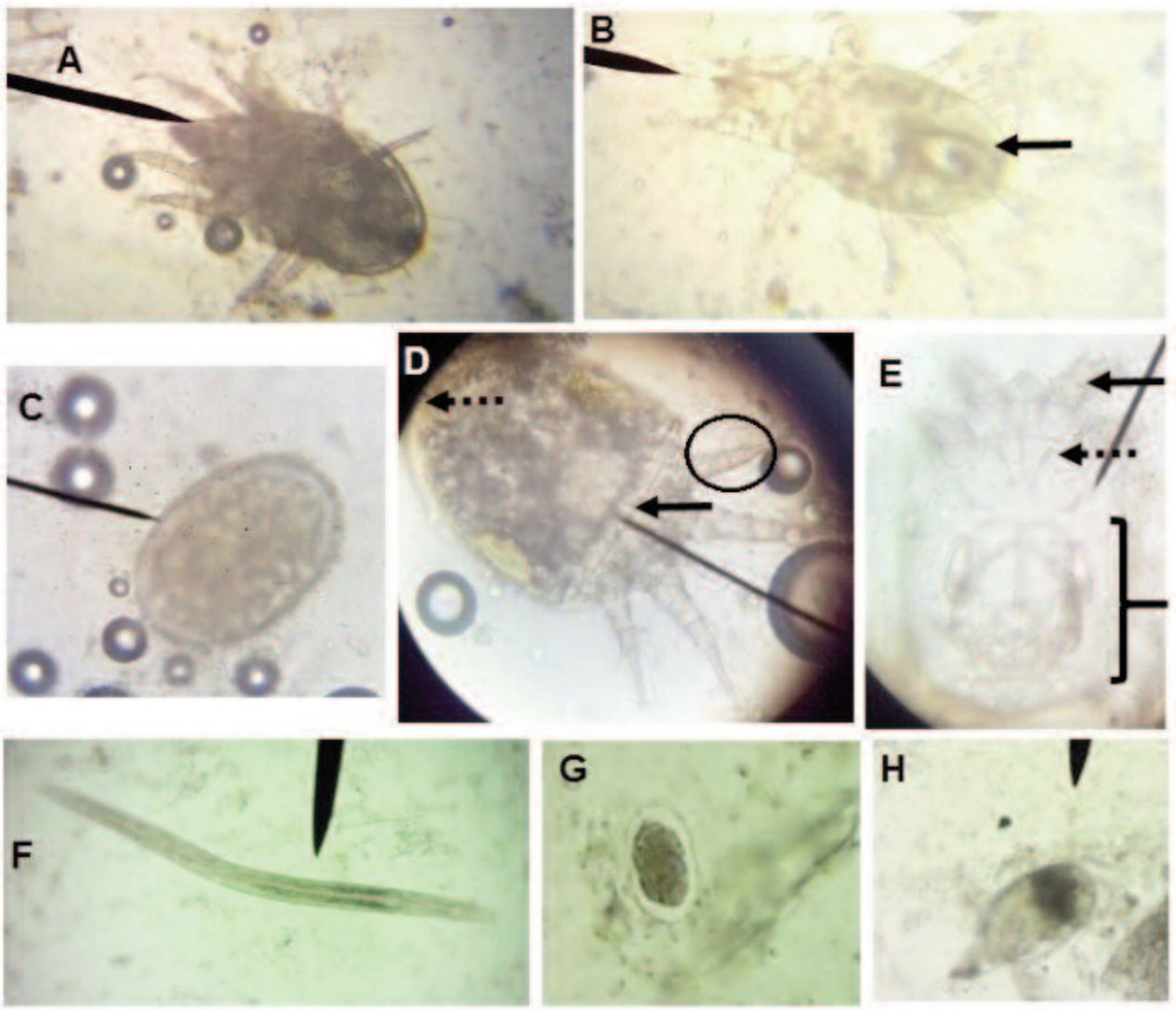

Figure 1. Endo- and ectoparasites identified at different stages in the surveyed broiler farms. A and B: adult *Ornithonyssus Sylviarum* showing teardrop-shaped anal plate (arrow); C: *O. sylviarum* egg; D: Phoretic deutonymph of *Acarus siro* showing enlarged leg genu and femur (circled area), idiosoma with a dorso-sejugal suture anteriorly (arrow) and a rounded posterior (dashed arrow); E. Adult *Sarcoptes scabiei* showing short anterior legs (arrow), third and fourth pair of legs not being visible from dorsal view (accolade) and epimers of the first pair of legs joining to the central rod (dashed arrow); F: *Ascaridia galli* L2 Larvae stage; G and H: *Ascaridia galli* eggs at blastula and earlier embryo-cell division stages respectively

The mixture was vortexed for 15–20 seconds and a volume of around 100 microliters of the mixture was immediately placed on a glass slide, using a disposable dropper, for light microscopy examination at 50–100× magnification. The process was repeated three times for each composite sample.

Preparation of intestinal contents for microscopic observation

The duodenum, jejunum, ileum and ceca collected from each sampled bird were cut open longitudinally and the entire contents were searched for adult forms of intestinal parasites. Around 0.3 g of the intestinal content of each part was scraped separately with the edge of a glass slide. A drop of sterile saline was added and mixed with the intestinal contents and the slide was covered under a cover-slip and observed under a light microscope with a magnification of 50–100×. The process was repeated twice for each intestinal part.

Parasites identification

The ectoparasites and intestinal helminths were identified according to their morphological characteristics under light microscopy at the Animal Research and Diagnostic Lab at the Faculty of

Table 2. Percentage of investigated farms with endo- or ectoparasites infestation

		Farming system							
		Semi-open				Closed			
Province		Akkar (North Lebanon)	Koura (North Lebanon)	Baabda (Mount Lebanon)	Total	Baabda (Mount Lebanon)	Jbeil (Mount Lebanon)	Tyre (South Lebanon)	Total
Number of farms		8	6	3	17	3	2	1	6
% of farms infected with:									
Chicken parasitic mites	Adult	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
	Eggs	100.0	50.0	33.3	70.6	100.0	0.0	0.0	50.0
Other mites	Adult	0.0	33.3	0.0	11.8	0.0	0.0	0.0	0.0
	Eggs	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Helminth	Adult	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
	Larvae	100.0	16.7	0.0	53.0^{a}	0.0	0.0	0.0	0.0^{b}
	Eggs	87.5	16.7	33.3	53.0	100.0	0.0	0.0	50.0
Mixed infestation (mites/helminths)		100.0	100.0	100.0	100.0^{a}	100.0	0.0	0.0	50.0^{b}

Explanations: ^{a,b} percentages in a row with different superscripts are significantly different ($P<0.05$)

Agricultural and Food Sciences at the American University of Beirut using parasite diagnostic guidelines and references [12–22].

Statistical analysis

The percentage of farms that were positive for endo- or ectoparasites was compared between semi-open and closed systems using Chi-square test at a significance level of 95%. The statistical software used in the study is SPSS V.25 (SPSS Inc., Chicago, IL, USA)

Results

Endo- and ectoparasites prevalence in each farming system

The ecto- and endoparasites observed in this study were limited to mites and nematodes respectively, including various life stages of each type. Interestingly, mites were prevalent in all of the investigated farms in both systems (Tab. 2). Moreover, not all of the observed mites were chicken-specific parasites; these were labeled as "other mites" in table 2 and were only found in adult stage in some of the semi-open farms (11.8%). Helminths were notably prevalent in almost half of the investigated farms while mites-helminths mixed infestation was more prominent in semi-open facilities (100%) in comparison to those adopting the closed system (50%; $P<0.05$) (Tab. 2).

Morphological identification of endo- and ectoparasites and their prevalence in semi-open or closed farms

Among the identified chicken ectoparasites, the northern fowl mite *Ornithonyssus sylviarum* (Fig. 1A–C) was significantly more prevalent in semi-open farms in comparison to the closed ones (88.2 vs. 50.0% respectively, $P<0.05$). The poultry red mite *Dermanyssus gallinae* infestation was much less observed in semi-open farms, recording around 6% positivity, and was absent in the closed facilities. The same pattern was observed for two other mite species that are not chicken-specific parasites, namely the grain mite *Acarus siro* (Fig. 1D) and the sarcoptic or mange mite *Sarcoptes scabiei* (Tab. 3, Fig. 1E).

With respect to intestinal helminths, eggs and stage 2 larvae of the chicken parasitic nematode *Ascaridia galli* were observed in almost half of the investigated farms while the adult stage of this nematode was not detected (Tab. 3, Fig. 1F–H).

Table 3. Prevalence of endo- and ectoparasite identified species in the investigated farms

	Farming system							
	Semi-open				Closed			
Province	Akkar (North Lebanon)	Koura (North Lebanon)	Baabda (Mount Lebanon)	Total	Baabda (Mount Lebanon)	Jbeil (Mount Lebanon)	Tyre (South Lebanon)	Total
Number of farms	8	6	3	17	3	2	1	6
% of farms infected with:								
Chicken parasitic mites								
Ornithonyssus sylviarum	100.0	66.7	100.0	88.2[a]	100.0	0.0	0.0	50.0[b]
Dermanyssus gallinae	0.0	16.7	0.0	5.9	0.0	0.0	0.0	0.0
Other mites								
Acarus siro	0.0	16.7	0.0	5.9	0.0	0.0	0.0	0.0
Sarcoptes scabiei	0.0	16.7	0.0	5.9	0.0	0.0	0.0	0.0
Helminths								
Ascaridia galli	100.0	16.7	33.3	58.8	100.0	0.0	0.0	50

Explanations: [a,b] percentages in a row with different superscripts are significantly different ($P<0.05$)

Discussion

There is abundant research that investigates the prevalence of endo- and ectoparasites in backyard and organic chicken layers which have a production lifespan of more than 1.5 year and are usually kept loose-housed and therefore more exposed to vectors and predators. On the other hand, the assessment of endo- and ectoparasite infestation in broiler farms under semi-open or closed system is an issue that has been rarely tackled by researchers, given the short lifespan of birds that are marketed at 5–6 weeks of age or probably underestimating the impact of these pests in a presumably controlled environment. The current study underlined the prevalence of endo- and ectoparasites in most of the investigated broiler farms in Lebanon. Adult parasitic mites were found in all of the semi-open and closed farms while their eggs were found in more than half of these facilities (Tab. 2) indicating a severe infestation with these ectoparasites that are reproducing massively. In Lebanon a thorough bactericidal and virucidal chemical disinfection of the barn is usually practiced between two broiler rearing cycles while neglecting the application of acaricides. This might be one of the reasons behind the flourishing parasitic mites' infestation in the investigated facilities along with the emergence of acaricide-resistant parasites [23]. The presence of other types of mites that are not chicken-specific parasites (Tab. 2) is another confirmation of the previous statement. Nevertheless, it also indicates the presence of external contaminants or vectors finding their way to enter the semi-open farms which are even more loose, in terms of implementing biosecurity measures, than the closed ones [24]. For the same reason, all of the Semi-open farms in this study showed mixed infection with mites and intestinal helminths.

The presence of larvae and eggs of helminths in more than half of the surveyed semi-open farms (Tab. 2) is equally alarming. The prevalence of helminth infection in poultry is influenced by various environmental factors that affect the population dynamics of the parasite itself and the animals that may act as reservoirs or vectors [25]. In other terms, helminth infection is indicative of farm management problems and poor biosecurity practices as well. Under poor farm management, high humidity and temperature constitute the perfect environment for the larvae of many helminths to survive outside the host body for prolonged periods

[12–14].

The most abundant mite identified in this study is the northern fowl mite *Ornithonyssus sylviarum* which was present in most of the semi-open farms and in half of the closed ones (Tab. 3, Fig. 1A, 1B). These results are not actually surprising, given that this mite is a common ectoparasite of poultry, wild birds and rodents worldwide [22] including countries of the MENA region [26–29]. Morphologically, adults and eggs of *O. sylviarum* species resemble those of other poultry ectoparasitic mites to a certain extent. However, *O. sylviarum* is readily distinguished through the anal shields of adult females that have a teardrop-shaped anal plate while eggs have the typical grayish rectangular shape [22] as shown in figure 1C. Unfortunately, only light microscopy was used in this study, otherwise the Scanning Electron Microscopy (SEM) would have helped identifying the claw-like chelicera and provided additional micrographs highlighting their shape that should be abruptly narrowed posteriorly, and epigynal dorsal shields that are narrowly rounded posteriorly [18].

The prevalence of *O. sylviarum* in most of the broiler farms investigated in this study raises the possibility of having this mite as an endemic parasite in poultry of Lebanon. Severe *O. sylviarum* infestation and economic damage usually occur in egg-laying chicken or breeders [5]; however, and given that this parasite infests wild birds and mammals including rodents, these animals apparently contribute to the endemicity of *O. sylviarum* in broiler farms as well.

Another poultry parasitic mite was identified in this study namely the Red Poultry mite or Roost mite *Dermatonyssus gallinae* that was prevalent in semi-open farms only (Tab. 3). In this study, *D. gallinae* was distinguished from other mites, specifically *O. sylviarum*, by comparing the body size, leg positioning, and shoulders of the dorsal shield. *D. gallinae* adults are larger than *O. sylviarum* and have prominent dorsal shield shoulders [18, 22]. SEM, not used in this study, would have provided more information about the chelicera that should be whip-like and the position of setae j1 and s1 and the epigynal pores, and the presence on tibia IV pl of the seta [18]. Similar to *O. sylviarum*, *D. gallinae* mites are transmitted to poultry via wild birds or rodents and cause serious economic problems to poultry farms worldwide, including MENA region [5,26,30,31] and now Lebanon. However, the very low prevalence of this parasitic mite in the surveyed farms in this study could stem from the fact that, unlike the northern fowl mite, *D. gallinae* mites spend only part of the time on chicken hosts, namely at night to feed, and then move and hide in crevices during the day [5]. Nevertheless, the presence of two poultry ectoparasites, namely the northern fowl mite and the red poultry mite in the surveyed broiler farms raises a red flag in regards to the biosecurity measures and basic managerial processes that are being implemented in the study area.

Among the identified mites, *Acarus siro* was prevalent in around 6% of the surveyed semi-open farms and was not present in closed farms (Tab. 3). *Acarus siro* is a not a chicken-specific parasite but a "stored grain pest" [32]. This mite was morphologically identified, at the phoretic deutonymph stage, by referring to the leg and idiosoma shape and structure. The leg genu and femur are enlarged while the idiosoma shows a dorso-sejugal suture anteriorly and has a rounded posterior [33,34] as shown in figure 1D obtained in this study. The grain mite is distributed worldwide and it is dominant in postharvest habitats and farm stores [35]; therefore its presence in few semi-open farms is strongly related to the stored feed infestation. Nevertheless it has peculiar growth conditions such as high humidity and low environmental temperature. It cannot grow in grains having less than 13% moisture nor withstand environmental temperatures greater than 31°C [35]. That is probably why its prevalence in the surveyed farms was very limited.

The itching mite *Sarcoptes scabiei* was also prevalent in around 6% of the investigated semi-open farms and not found in the closed facilities (Tab. 3). This mite is not a poultry parasite; however, it is an infectious ectoparasite that causes mange or scabies among wildlife mammals, domestic animals and humans [36]. Adult *Sarcoptes scabiei* was morphologically identified in this study based on: 1) its small round body shape, 2) short legs, 3) third and fourth pair of legs (posterior) not being visible from dorsal view, and 4) epimers of the first pair of legs join to the central rod (Fig. 1E). Unlike *Acarus siro*, the prevalence of this mite in poultry farms is not related to stored feed contamination; however, it is indicative of mediocre biosecurity conditions granting rodents or other *S. scabiei* mammalian hosts easy access to the farms. Moreover, sarcoptic mites typically do not survive more than 72 hours off of their host, but may persist

for several days depending on the environmental conditions, specifically high humidity that prevent mites from dehydrating rapidly thus prolonging its survival outside of the host rapidly [36]. Therefore, the presence of *S. scabiei* in poultry underlines poor management of the farms that were surveyed in this study, specifically the control of humidity due to poor ventilation and the presence of rodents in these farm and in the feed storage facilities as well.

This work revealed the presence of the avian intestinal nematode *Ascaridia galli* in half of the surveyed farms in both rearing systems (Tab. 3). Fortunately, boundless literature describes the morphology of various stages of this nematode and has been used in this study for identification purpose [13–16,37,38]. Only eggs at early development stage, including blastula (Fig. 1G, H), and L2 larval stadium of this nematode (Fig. 1F) were identified in this work. while adult roundworm individuals were completely absent. The fact that *Ascaridia galli* worms pass through four larval stages spending around 30 days before they mature could be the reason why adult worms of this species were not detected in broilers [5]. Most probably, the hardiness of *A. galli* eggs in the outdoor environment and neighboring pastures can act as continuous source of infection to new flocks [38]. It is worth noting that these roundworms are reported worldwide, specifically in backyard or organic egg-laying chicken [37,38]. Nevertheless, this study proves further that *A. galli* can raise red flags in semi-open and closed poultry farms that should have been implementing proper biosecurity measures.

This work reported the prevalence of several parasites in semi-open and closed broiler farms in Lebanon. It identified and documented for the first time three chicken-specific parasites namely the northern fowl mite *Ornithonyssus sylviarum*, the poultry red mite *Dermanyssus gallinae* and the intestinal helminth *Ascaridia galli*. The fact that *Ornithonyssus sylviarum* was the predominant ectoparasite in most of the surveyed farms in both systems suggests its potential endemicity in poultry of Lebanon.

Two mites species, the itching mite *Sarcoptes scabiei* and the grain mite *Acarus siro* had minor prevalence in semi-open farms only. Although these two species are not chicken parasites, their presence unveil serious problems; *Sarcoptes scabiei* indicates poor farm biosecurity and management while *Acarus siro* underline stored poultry feed infestation.

Poultry endo- and ectoparasites are often overlooked although their prevalence is alarming as revealed in this work. Based on the findings, an action plan ought to be taken to control these pests starting with the implementation of proper management and biosecurity measures including vector control along with the application of safe and efficient acaricides and helminticides. The outcomes of controlling these parasites in poultry farms of Lebanon will be beneficial for the farmers and consequently for the agonizing economy of this country.

References

[1] Alasadiy Y.D.K., Alhasnawi A.N., Eabaid F.A. 2020. The prevalence of parasitic infection in domestic chicken: a review. *Medico-Legal Update* 20(1): 864–869. doi:10.37506/v20/i1/2020/mlu/194434

[2] Al-Zubaidei H.H. 2015. Isolation and identification of some ecto- and endoparasites on native chickens in Diyala province. *Al-Qadisiyah Journal of Veterinary Medicine Sciences* 14(2): 1–5.

[3] Abdullah S.H., Mohammed A.A. 2013. Ecto- and endoparasites prevalence in domestic chickens in Sulaimani region. *The Iraqi Journal of Veterinary Medicine* 37(2): 149–155.

[4] Sparagano O., Pavlićević A., Murano T., Camarda A., Sahibi H., Kilpinen O., Mul M., van Emous R., le Bouquin S., Hoel K., Cafiero M.A. 2009. Prevalence and key figures for the poultry red mite *Dermanyssus gallinae* infections in poultry farm systems. *Experimental and Applied Acarology* 48(1–2): 3–10. doi:10.1007/s10493-008-9233-z

[5] Hinkle N., Hickle L. 2008. External parasites and poultry pests. In: Diseases of poultry. (Eds. Y.M. Saif, A. Fadly, J.R. Glisson, L.R. MsDougald, L.K. Nolan, D.E. Swayne). 12th ed. Blackwell Pub. Ames, Iowa: 1011–1024.

[6] Mundaganur D., Mundaganur Y. & Ashokan K. 2017. A comparative study of ecto- and endoparasites of free range and captive Fowl in Sangli District, Maharashtra. *GSC Biological and Pharmaceutical Sciences* 1(3): 54–58.

[7] Gimba F.I., Ola-Fadunsin S.D., Abdullah D.A., Konto M., Daudu B.B., Abubakar D. 2019. Prevalence of endo- and ectoparasites of chickens in some villages in Taraba state, North-Eastern Nigeria. *Livestock Research for Rural Development* 31: article number 50. http://www.lrrd.org/lrrd31/4/olash31050.html

[8] Mozafar F. 2014. [The red mite, a major challenge for egg producers]. Spring event: German Association for Poultry Science. Leipzig, March 11–12, 2014 (in German).

[9] Sharma N., Hunt P.W., Hine B.C., Ruhnke I. 2019. The impacts of *Ascaridia galli* on performance, health, and immune responses of laying hens: new insights into an old problem. *Poultry Science* 98(12): 6517–6526. doi:10.3382/ps/pez422.

[10] Valiente Moro C., De Luna C.J., Tod A., Guy J.H., Sparagano O.A., Zenner L. 2009. The poultry red mite (*Dermanyssus gallinae*): a potential vector of pathogenic agents. *Experimental and Applied Acarology* 48(1–2): 93–104. doi:10.1007/s10493-009-9248-0

[11] Kassem Y., Gökçekuş H., Aljamal J. 2019. Surface water resource and effect of weather parameters in estimating the annual rainfall: a case study in Lebanon. IOP Conference Series: Materials Science and Engineering, Vol. 800, 5th International Conference on New Advances in Civil Engineering (ICNACE 2019), 8–9 November, 2019, Kyrenia, Cyprus. doi:10.1088/1757-899X/800/1/012028

[12] Reid W.M. 1960. Effects of temperature on the development of the eggs of *Ascaridia galli*. *The Journal of Parasitology* 46(1): 63–67.

[13] Feyera T., Ruhnke I., Sharpe B., Elliott T., Campbell D.L.M., Walkden-Brown S.W. 2020. Viability and development of *Ascaridia galli* eggs recovered in artificial media followed by storage under different conditions. *Journal of Helminthology* 94: e199. doi:10.1017/s0022149x2000084x

[14] Thapa S., Thamsborg S.M., Meyling N.V., Dhakal S., Mejer H. 2017. Survival and development of chicken ascarid eggs in temperate pastures. *Parasitology* 144(9): 1243–1252. doi:10.1017/s0031182017000555

[15] Tanveer S., Ahad S., Chishti M.Z. 2015. Morphological characterization of nematodes of the genera *Capillaria, Acuaria*, *Amidostomum*, *Streptocara, Heterakis*, and *Ascaridia* isolated from intestine and gizzard of domestic birds from different regions of the temperate Kashmir valley. *Journal of Parasitic Diseases* 39(4): 745–760. doi:10.1007/s12639-013-0401-7

[16] Sheikh B.A., Ahmad F., Sofi T.A. 2016. Morphology and prevalence of some helminth parasites in *Gallus domesticus* from Gurez Valley of Jammu and Kashmir, India. *Journal of Fisheries and Livestock Production* 4(1): article number 159. doi:10.4172/2332-2608.1000159

[17] Kumar S., Garg R., Ram H., Maurya P.S., Banerjee P.S. 2015. Gastrointestinal parasitic infections in chickens of Upper Gangetic plains of India with special reference to poultry coccidiosis. *Journal of Parasitic Diseases* 39(1): 22–26. doi:10.1007/s12639-013-0273-x

[18] Di Palma A., Giangaspero A., Cafiero M.A., Germinara G.S. 2012. A gallery of the key characters to ease identification of *Dermanyssus gallinae* (Acari: Gamasida: Dermanyssidae) and allow differentiation from *Ornithonyssus sylviarum* (Acari: Gamasida: Macronyssidae). *Parasites and Vectors* 5: article number 104. doi:10.1186/1756-3305-5-104

[19] Wall R., Shearer D. 1997. Veterinary entomology: arthropod ectoparasites of veterinary importance. 1st ed. Springer Science and Business Media B.V., UK.

[20] Schmidt-Rhaesa A. 2013. Handbook of zoology: Gastrotricha, Cycloneuralia and Gnathifera Vol. 2. De Gruyter GmbH (Pub), Germany.

[21] Mehlhorn H. 2016. Animal parasites. Springer International Publishing, Switzerland.

[22] Murillo A.C., Mullens B.A. 2017. A review of the biology, ecology, and control of the northern fowl mite, *Ornithonyssus sylviarum* (Acari: Macronyssidae). *Veterinary Parasitology* 246: 30–37. doi:10.1016/j.vetpar.2017.09.002

[23] Marangi M., Morelli V., Pati S., Camarda A., Cafiero M.A., Giangaspero A. 2012. Acaricide residues in laying hens naturally infested by red mite *Dermanyssus gallinae*. *PLoS One* 7(2): e31795. doi:10.1371/journal.pone.0031795

[24] Jansson D.S., Nyman A., Vågsholm I., Christensson D., Göransson M., Fossum O., Höglund J. 2010. Ascarid infections in laying hens kept in different housing systems. *Avian Pathology* 39(6): 525–532. doi:10.1080/03079457.2010.527923

[25] Ola-Fadunsin S.D., Uwabujo P.I., Sanda I.M., Ganiyu I.A., Hussain K., Rabiu M., Elelu N., Alayande M.O. 2019. Gastrointestinal helminths of intensively managed poultry in Kwara Central, Kwara State, Nigeria: its diversity, prevalence, intensity, and risk factors. *Veterinary World* 12(3): 389–396. doi:10.14202/vetworld.2019.389-396

[26] Mumcuoglu K.Y., Lutsky I. 1990. A prevalence survey of poultry house mites in Israel. *Acarologia* 31(1): 51–56. https://www1.montpellier.inra.fr/CBGP/acarologia/export_ pdf.php?id=2489&typefile=1

[27] Ahmed N., Ahmed A.M. 2020. *Ornithonyssus sylviarum* (Acari: Gamasida: Macronyssidae) a cause of pruritic dermatitis for poultry farm workers in Sohag Governorate, Egypt. *Journal of the Egyptian Society of Parasitology* 50(3): 599–604. doi:10.21608/jesp.2020.131092

[28] Moodi B., Aliabadian M., Moshaverinia A., Mirshamsi Kakhki O., Faraji F. 2014. Mites associated with passerine birds in eastern Iran. *International Journal of Acarology* 40(2): 133–137. doi:10.1080/01647954.2014.888094

[29] Shayan A., Rafinejad J. 2006. Arthropod parasites of rodents in Khorram Abbad district, Lorestan province of Iran. *Iranian Journal of Public Health* 35(3): 70–76.

[30] Ghalejoughe E.M., Tavassoli M., Naem S. 2017. *Dermanyssus gallinae* (Acari, Mesostigmata) in the Barn Swallow (*Hirundo rustica*) nests in Urmia suburb, North West of Iran. *Persian Journal of*

Acarology 6(2): 95–102. doi:10.22073/pja.v6i2.25603
[31] Sparagano O., Ho J. 2020. Parasitic mite fauna in Asian poultry farming systems. *Frontiers in Veterinary Science* 7: article number 400. doi:10.3389/fvets.2020.00400
[32] Cunnington A.M. 1965. Physical limits for complete development of the grain mite, *Acarus siro* L. (Acarina, Acaridae), in relation to its world distribution. *Journal of Applied Ecology* 2(2): 295–306. doi:10.2307/2401481
[33] Klimov P., O'Connor B., Ochoa R.G., Bauchan A., Redford A., Scher J. 2016. *Acarus*. USDA-University of Michigan. http://idtools.org/id/mites/beemites/factsheet.php?name=15314
[34] Melnyk J.P., Smith A., Scott-Dupree C., Marcone M.F., Hill A. 2010. Identification of cheese mite species inoculated on Mimolette and Milbenkase cheese through cryogenic scanning electron microscopy. *Journal of Dairy Science* 93(8): 3461–3468. doi:10.3168/jds.2009-2937
[35] Trematerra P., Throne J.E., Fernandez M., Knox R. 2012. Insect and mite pests of durum wheat. In: Durum wheat chemistry and technology. (Eds. M. Sissons, Abecassis, B. Marchylo, M. Carcea). 2nd ed. St. Paul, MN: AACC International, Inc.: 73–83.
[36] Office International des Epizooties. 2019. *Sarcoptes scabiei*. https://www.oie.int/app/uploads/2021/03/sarcoptes-scabiei-infection-with.pdf
[37] Yazwinski T.A., Tucker C.A. 2008. Nematodes and acanthocephalans. In: Diseases of poultry. (Eds. Y.M. Saif, A. Fadly, J.R. Glisson, L.R. MsDougald, L.K. Nolan, D.E. Swayne). 12th ed. Blackwell Pub. Ames, Iowa:1025–1056.
[38] Kates K.C., Colglazier M.L. 1970. Differential morphology of adult *Ascaridia galli* (Schrank, 1788) and *Ascaridia dissimilis* Perez Vigueras, 1931. *Proceedings of the Helminthological Society of Washington* 37: 80–84.

Received 10 January 2022
Accepted 02 April 2022