



Special Issue:

Emerging and Re-emerging Animal Health Challenges in Low and Middle-Income Countries

Impact of *Trichomonas gallinae* in the Infected Domestic Pigeon and Antitrichomonal Potentials of Garlic

RAND KAMIL ABBAS, ZAHRA SADOON HADI*, AHMAD HASSAN SAHIB

Department of Biology, College of Education for women, University of Al-Shatrah, Iraq.

Abstract | The purpose of this study is to determine the presence and pathological impact of trichomoniasis among pigeons. Additionally, we aim to investigate antitrichomonal potentials of garlic. For these purposes, a total of 50 birds were collected from a tower building and tested for trichomoniasis using the wet mount method. Pigeons were divided into three groups: The control group (n=10 birds) was not diseased and received no therapy. The second group (n=20 birds) were positive for trichomoniasis but didn't receive treatment. The third group (n=20 birds) were infected and treated with garlic (200 mg/kg of aqueous garlic extracts for seven days). The impact of parasites on various blood parameters were investigated and died animals were examined for gross and histological changes. The results revealed that trichomonas had affected the blood picture, decreased Hb and PCV concentrations while dramatically increasing WBC with no discernible effect on RBCs. On the other hand, garlic possessed beneficial effects on blood parameters and bird health. Gross clinical changes include yellowish white caseous necrotic haemorrhagic lesions in the upper digestive system, starting from the oral cavity, and also present in the liver. Histopathologically, there was an infiltration of large number of mononuclear inflammatory cells in the tracheal mucosa. Sinusoidal congestion and Kupffer cell hyperplasia were seen in the liver. Taken together, our finding articulates that garlic (200 mg/kg) offers natural, cheaper and potent antitrichomonal therapy.

Keywords | *Trichomonas gallinae*, Pathological, Garlic, Blood parameters

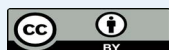
Received | July 11, 2024; **Accepted** | September 19, 2024; **Published** | November 13, 2024

***Correspondence** | Zahra Sadoon Hadi, Department of Biology, College of Education for women, University of Al-Shatrah, Iraq; **Email:** Zahra@shu.edu.iq

Citation | Abbas, R.K., Hadi ZS, Sahib AH (2024). Impact of *Trichomonas gallinae* in the infected domestic pigeon and antitrichomonal potentials of garlic. J. Anim. Health Prod. 12(s1): 86-92.

DOI | <http://dx.doi.org/10.17582/journal.jahp/2024/12.s1.86.92>

ISSN (Online) | 2308-2801



Copyright: 2024 by the authors. Licensee ResearchersLinks Ltd, England, UK.

This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (<https://creativecommons.org/licenses/by/4.0/>).

INTRODUCTION

Trichomonas gallinae is a protozoan parasite with four free flagella emerging from a basal granule at the organism's frontal pole and an undulating membrane flagellates (Muzeal and Khudeir, 2022). The parasite infects wild and domestic bird species all over the world, and is located in the upper digestive tract, liver, air sacs, and parts of the cranium (Alrefaei, 2020). One of the major hosts of *T. gallinae* is the local pigeon (*Columba livia domestica*). In pigeons, the disease is known as canker, contributes significantly to the disease's transmission

(Fadhil and Faraj, 2019). Despite its preference for pigeons and doves, *T. gallinae* can infect a broad variety of bird families, including chickens, turkeys, raptors and bustards (Mohamed et al., 2023). The parasite is transmitted from host to another without need to an intermediate host. It established an infection when it is passed via crop milk from infected parent birds to squabs, but it can also occur through direct contact between healthy and infected adult birds while feeding or drinking. It causes significant losses and increased mortality, particularly in young birds (Ji et al., 2020). Trichomonosis is a clinical infection, its symptoms characterized by excessive salivation, inflammatory mucosa

and oral lesions affecting the soft palate, tongue, and mouth, appearance of yellow and caseous lesions in the upper digestive tract (Fadhil et al., 2020).

Symptoms may be disappeared after some days or may persist, restricting feeding and ended in death. However, symptoms were included ruffled feathers (Hammadi et al., 2023) hunched posture, closed eyes, and gasping for air. Near-death, birds lose their ability to perch and/or stand. Cankers are made of blood cells (mainly leucocytes), tissue debris, decrepit parasites, and other components, and appear to represent a host response against trichomonads (Hamad and Hassan, 2017; Thomas, 2017).

Humans have utilized garlic (*Allium sativum*) as herb or spices, over the decades. Garlic is known for their antibacterial, antithrombotic, antiarthritic, hypolipidemic, and hypoglycemic properties. While some findings allude to the use of garlic as antiprotozoal (Sadr et al., 2022), a systematic analysis of garlic as antitrichomonal therapy remain elusive.

In view of the spread of the pigeon breeding hobby and the lack of studies in *T. gallinae*, the current study aims to confirm the prevalence and to study the pathology of *T. gallinae* in local pigeons. Additionally, the study aims to investigate the antitrichomonal effect of garlic.

MATERIALS AND METHODS

SAMPLES

Birds were taken from a tower building at Thi-Qar city south of Iraq between December 2022 to October 2023, suffering from severe diarrhea, ruffled feathers, cease eating, weaknesses and torsion of the head.

EXAMINATION

The diagnosis of *T. gallinae* was confirmed by observing the parasites in direct smear mount preparations of specimens collected from mouth and esophagus using sterile swabs and placed in 0.5 ml sterile normal saline concentration 0.9% and kept warm at 20-30°C until arriving to the laboratory. Samples were examined for motile protozoan within 30 minutes, and specimens were examined under light microscope under 10X and 40X magnification to detection jerky movement of trichomonads (Samour and Naldo, 2003).

STAINING METHOD

A smear was made from specimens of fluid and oesophageal swabs, dried and stained with Giemsa after being fixed with osmic acid. Trichomonad was diagnosed according to the method of (Soulsby, 1986), under 400X and 1000X magnification.

EXPERIMENTAL GROUPS

Fifty squabs were divided into three groups. The first group (control 10 birds) was containing wholesome uninfected birds. The second and third groups (20 birds each) were infected, the second group left without treatment, while the third group was with garlic for 7 days.

TREATMENT

The treatment consisted of adding (200 mg/ml) of (AGE) to consuming water for seven days (Seddiek et al., 2014).

EXTRACT OF GARLIC

Garlic extract (*Allium sativum* Linn: Liliaceae): aqueous garlic extract (AGE) was prepared and dried according to the method described by Gharavi et al. (2011).

HISTOLOGICAL INVESTIGATIONS

Tissue samples of the pigeons such as the liver and oropharynx were prepared by routine histological techniques (Bancroft and Steven, 2012) and stained with Haematoxylin and Eosin for histological examination.

HEMATOLOGICAL ANALYSIS

Blood samples were obtained from each squab's jugular vein before and after therapy. Hematological tests such as hemoglobin, erythrocytic, total, and differential leukocytic counts were determined (Schalm, 1986).

STATISTICAL ANALYSIS

The Chi square test using SPSS (version 17) for Windows was performed for comparing the efficacy of the two-culturing media (Villanua et al., 2006).

RESULT AND DISCUSSION

GROSS LESIONS

Post-mortem examination showed several signs in the trachea such as congestion, exudates and haemorrhage. There was yellowish- white caseous plug in mouth, this caseous masses were different in sizes among infected birds and may continue in the mucous membranes of the esophagus (Figure 1). Small yellow spots were found in the liver, with pale necrotic areas (Figure 2).

HISTOLOGY

There was a slight to moderate invasion of mononuclear inflammatory cells in the larynx and pharynx lamina propria. The tracheal mucosa had significant foci of mononuclear inflammatory cells. Mucous cell hyperplasia was also seen in the epithelia of the trachea. The oesophageal submucosal glands were swollen. Huge inflammatory cell infiltration was found in the pharyngeal wall (Figure 3 and Figure 4).



Figure 1: The lesion in buccal cavity of infected pigeon.

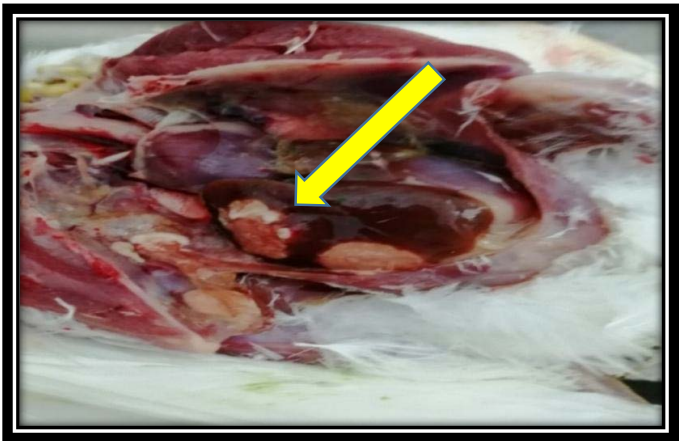


Figure 2: The lesion in liver of infected pigeon.

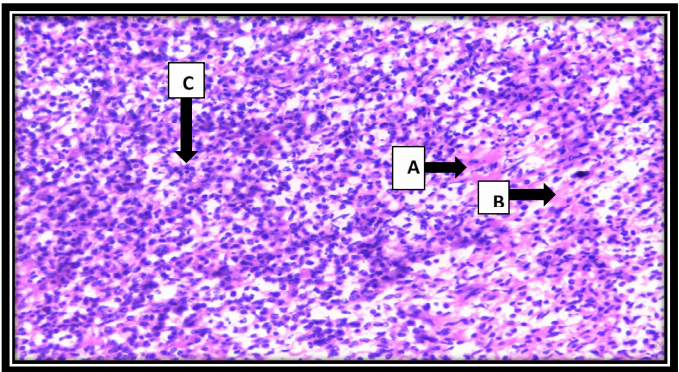


Figure 3: Light photographs of section in the larynx show heavy mixed inflammatory cells infiltration (Lymphocytes, macrophages and neutrophils) (A, B) and vascular proliferation (C).

LIVER

Pigeon liver moderately infected with *T. gallinae* exhibiting increased hepatocyte necrosis with mononuclear inflammatory cell infiltration, hyperemia, and bile duct hyperplasia. In birds that are heavily infected, there were several granulomatous foci in the liver, multinucleated giant cells, sinusoidal congestion and Kupffer cell hyperplasia (Figure 5).

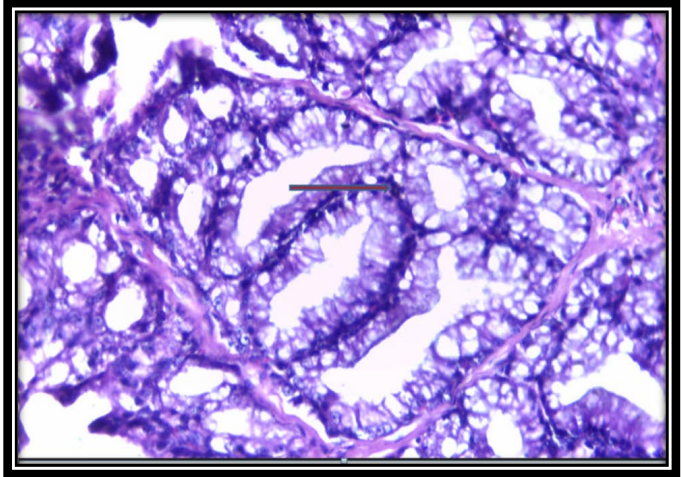


Figure 4: Section in the larynx shows hypertrophy and hyperplasia of mucous secreting gland.

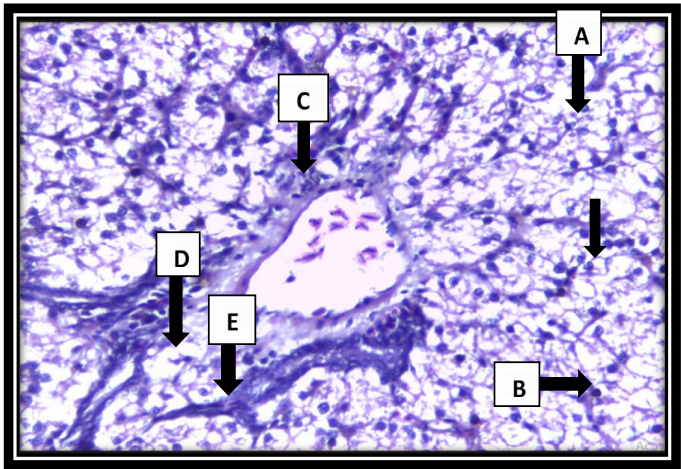


Figure 5: Light photographs of section in the liver shows necrosis of hepatocytes (A, B), bile duct proliferation (C). Mononuclear cell infiltration (mainly lymphocytes) (D), sinusoidal congestion and Kupffer cells hyperplasia.

TREATMENT OF GARLIC

Garlic displayed ability as an anti-trichomonal phytotherapy, the infected birds treated by garlic for 7 days showed significantly lower mortality rates (12.5% vs. 65% in infected untreated group), and the majority of the birds were free from the infection and completely cured (Table 1).

Table 1: The mortality recorded in different groups.

Groups	No.	Mortality	%
Control (-ve)	10	0	0
Infected (without treatment)	20	13	65
Infected (treated with garlic)	20	5	12.5
Total	50	18	36
X =6.969 P= 0.0307			

Garlic treatment resulted in an improvement in body weight, and pigeon's buccal cavity appears healthy,

with no caseated mass (Figure 6). The liver of a treated pigeon appears healthy, with no necrotic foci (Figure 7). Histological lesions in the trachea and liver disappeared after garlic treatment.



Figure 6: Buccal cavity of pigeon after treatment by garlic showing no caseous mass.



Figure 7: The liver of pigeon after treatment by garlic showing no necrotic foci.

HEMATOLOGICAL PARAMETERS

The result indicated that *Trichomonas* had an effect on the blood picture, with a substantial decrease in Hb and PCV concentrations ($P>0.05$), with increased of WBC significantly with no effect on RBC. Our hematological results showed that the infected group had anemia. Two weeks after being treated with AGE, the anemic groups showed signs of recovery (Table 2).

In this study, a limited number of infected pigeons showed clinical symptoms. This can be explained by the fact that the carcasses of animals with severe disease symptoms are quickly consumed by carnivores (Borji et al., 2011). Before this study, little was known about *T. gallinae*, and comprehensive examinations showed the presence of

yellowish-white caseous masses in the trachea and mouth. The same lesions were reported by Saikia et al. (2021). The examination also showed the presence of caseous obstruction in the mouth, which consists of yellowish-white cystic masses, as well as yellowish-green secretions from the mouth with a foul odor. These signs were also recorded in other studies such as Echenique et al. (2019) and in Dhi Qar by Musa and Hamid (2023). Oral trichomoniasis is an emerging disease in many regions of the world, affecting wild species and there are no previous records of the disease to determine its exact prevalence (Lawson et al., 2011). The lesions of oral candidiasis, fowl pox (poxvirus), and vitamin deficiency must be distinguished from trichomoniasis because the oral lesions in these diseases resemble those seen in trichomoniasis (McDougald, 2013).

Microscopic study using Giemsa stain revealed clear *Trichomonas gallinae* protozoa with dark purple nuclei and light purple cytoplasm, which are the same morphological characteristics indicated by Fadhil and Faraj (2019) for *Trichomonas gallinae* isolated from pigeons. The appearance of small yellow spots distributed throughout the liver was consistent with the findings of Jafar et al. (2014). This is also supported by the findings of (Raza et al., 2018) who observed localized necrotic abscesses in all hepatic lobes accompanied by an inflammatory reaction determined by heterogeneous cells and mononuclear cells. The ability of parasites to reach internal organs is due to immune dysfunction and the virulence of the parasite. Virulence is also affected by previous exposure to pathogens, immunity, age, concomitant diseases, and genetic variability (Dunn et al., 2023).

From a histological perspective, multifocal granulomatous ulcerative stomatitis appeared in all birds, which partially obstructs the entrance to the larynx, as observed by Elbahy et al. (2023). Similar lesions were also described by Al-Saadi and Hamoudi (2011) in naturally occurring as well as experimentally induced trichomoniasis in pigeons, which supports our findings. In contrast to our findings, Begum et al. (2008) did not observe microscopic lesions in the phalanx. The variation in disease lesions may be due to differences in the virulence of infectious strains. The disease caused by non-virulent strains might have contributed to absence of any lesions or the lesion may be in subclinical stage (Saikia et al., 2021).

Table 2: The effect of the parasite on some blood parameters of infected and healthy birds.

Parameter	Control (-ve)	Infected (without treatment)	Infected (with treatment)	LSD
Hb (g/dl)	11.221 ± 0.043 ^a	7.80 ± 1.4 ^c	10.701 ± 0.381 ^b	0.48
PCV (%)	38.4 ± 0.3 ^a	25.2 ± 0.5 ^c	30.5 ± 0.4 ^b	2.56
RBC (×10 ⁶ /mm ³)	2.913± 0.014 ^a	2.556 ± 0.017 ^c	2.733± 0.17 ^b	0.16

We also observed patches of hepatocellular necrosis, bile duct hyperplasia, hyperemia, and the infiltration of heterophils and mononuclear inflammatory cells in the livers were observed in birds with a moderate infestation, but in highly infested birds, multiple multinucleated giant cells were observed in the livers with several granulomatous foci, these results were in agreement with that recorded by Borji et al. (2011) in Iran. Who additionally recorded hyperemia and bile duct hyperplasia in moderately infected pigeons.

We recorded 36% of the tested pigeons were infected with *T. gallinae*, where others pointed to that the percentages of infection reach 58.33% (Jafar et al., 2014). On the other hand, this study differed from some previous studies that recorded a lower rate of infection with this parasite (6.6% by Jawad et al., 2020). The differences in the infection rates return to several reasons, including size of the sample, the geographical location of the studied area and the surrounding environmental conditions where temperature and humidity are considered important factors affecting the life cycle of the this parasites (Robinson et al., 2010).

The mortality rate of the infected birds group left without treatment was 65%, which was in agreement with the result of Stoute et al. (2009). However, Al-Sadi and Hamodi (2011) have recorded a greater rate of mortality in younger birds. Pigeon gathering around feeders or water sources, along with increasing population stress, may encourage the spread of the infection and result in necrotic lesions that eventually kill the victim. Death rates in the garlic treated group dropped dramatically, this outcome complies with Seddiek et al. (2014). Garlic may have an impact on mortality because it enhanced the immunity and possessed antiprotozoal effect exactly, antitrichomonal action that could explain its efficacy in reducing mortality rate (Dkhil et al., 2011), it also possessed an additional antioxidant, anti-microbial, anti-inflammatory and hepatoprotective effects (Kocia-Tanackov et al., 2009; Dkhil et al., 2011) which increased its therapeutic efficacy.

The main treatment for avian trichomoniasis is nitroimidazole, but long-term use could lead to drug resistance and drug residues which represent a public health problem for those consume pigeons. Unfortunately, no vaccine is currently available for the treatment and prevention of *T. gallinae* (Xiang et al., 2023). Therefore, garlic represent a good alternative therapy for wide range of parasitic infections (Seddiek et al., 2014; Hanieh et al., 2010). The major components of garlic that possessed antiprotozoal effects and enhanced immune functions were allicin, ajoene, and organosulfides (Rehman and Munir, 2015).

The parasitic infection adversely affected the studied hematological parameters which consistent with previous finding (Abed, 2013; Saleem et al., 2008; Seddiek et al., 2014). This effect could be attributed to the inability of the infected bird to eat or drink, in addition that oral and pharyngeal lesions prevented food and water intake. Garlic treatment improve appetite and cured oral lesions therefore it improved the hematological parameter to near normal limits (Abed, 2013; Saleem et al., 2008; Seddiek et al., 2014; Bonaventura et al., 2010).

CONCLUSIONS AND RECOMMENDATIONS

The current study showed that trichomoniasis adversely changed the blood picture, decreasing Hb and PCV concentrations while dramatically increasing WBC with no discernible effect on RBCs. Gross clinical changes include yellowish white caseous necrotic haemorrhagic lesions in the upper digestive system, starting from the oral cavity, and also present in the liver. Histopathologically, there was infiltration of large number of mononuclear inflammatory cells in the tracheal mucosa. Sinusoidal congestion and Kupffer cell hyperplasia were seen in the liver. Garlic decrease the mortality rate among the infected bird, possessed beneficial effect on blood parameters and histological changes, and the majority of the treated birds were cured, which clearly indicated that garlic is a potent antitrichomonal therapy.

ACKNOWLEDGMENT

The authors express their sincere thanks to the technical support and infrastructure provided by Research Laboratories and Department of Biology, College of Education for women, University of Al-Shatrah, Iraq.

NOVELTY STATEMENT

This research was studied due to the importance of pigeons as domesticated birds and they are of great importance to breeders in Thi Qar Governorate. Also, studies on the *Trichomonas* parasite that infects birds are few in the governorate, which encouraged us to conduct this study and clarify the effect of infection and how to treat it using garlic, which is an antioxidant that plays a role in reducing infection with the parasite and eliminating it. This study is the first of its kind in the governorate.

AUTHOR'S CONTRIBUTION

The first author contributed to preparing the research idea, collecting samples, isolated and diagnosed parasite, stained

samples and writing the research. The second author contributed to collecting samples, isolated and diagnosed parasite, stained samples and writing the research, blood parameters work. and supervising it. The third author contributed to preparing and providing the necessary materials to complete the research method, analyze the results, and completing histosection.

CONFLICT OF INTEREST

The authors have declared no conflict of interest.

REFERENCES

- Abed AAA (2013). The incidence of *Trichomonas* in the dove (*Streptopelia decaocto*) and pigeon (*Columba livia*) at Al-Diwaniya city and its effects on blood picture. Coll. Vet. Med. Univ. Al-Qadisiya, 12(1): 72-77.
- Alrefaei AF (2020). Molecular detection and genetic characterization of *Trichomonas gallinae* in falcons in Saudi Arabia. PLoS One, 15(10): e0241411. <https://doi.org/10.1371/journal.pone.0241411>
- Al-Sadi HI, Hamodi AZ (2011). Prevalence and pathology of trichomoniasis in free-living urban pigeons in the City of Mosul. Iraq Vet. World, 4(1): 12-14. <https://doi.org/10.5455/vetworld.2011.12-14>
- Bancroft J, Steven A (2012). Theory and practice of histological techniques. 7th ed. London: Churchill livingstone: pp. 440-457.
- Begum N, Rahman SAM, Bari ASM (2008). Epidemiology and pathology of *Trichomonas gallinae* in the common pigeon (*Columba livia*). J. Bangladesh Agric. Univ., 6(20): 301-306. <https://doi.org/10.3329/jbau.v6i2.4826>
- Bonaventura J, Rodriguez EN, Beyley V, Vega IE (2010). Alkylation of intraerythrocytic hemoglobin by raw garlic extracts. J. Med. Food, 13(4): 943-949. <https://doi.org/10.1089/jmf.2009.0258>
- Borji H, Razmi GH, Movassaghi AH, Moghaddas E, Azad M (2011). Prevalence and pathological lesion of *Trichomonas gallinae* in pigeons of Iran. J. Parasit. Dis., 35(2): 186-189. <https://doi.org/10.1007/s12639-011-0047-2>
- Dkhil MA, Abdel-Baki AS, Wunderlich F, Sies H, Al-Quraishy S (2011). Anticoccidial and antiinflammatory activity of garlic in murine *Eimeria papillata* infections. Vet. Parasitol., 175(1-2): 66-72. <https://doi.org/10.1016/j.vetpar.2010.09.009>
- Dunn JC, Thomas RS, Hipperson H, Sheehan DJ, Orsman C, Mallord J, Goodman SJ (2023). Evidence for strain-specific virulence of *Trichomonas gallinae* in African columbiformes. Parasitology, 150(2): 206-211. <https://doi.org/10.1017/S0031182022001652>
- Echenique JVZ, Soares MP, Bruni M, Farias AN, Moretti VD, Bandarra PM, Albano AP, Schild AL (2019). Oral trichomoniasis in raptors <https://doi.org/10.21608/jcvs.2023.296058> in Southern Brazil. Pesq. Vet. Bras., 39(12): 983-988. <https://doi.org/10.1590/1678-5150-pvb-6077>
- Elbahy N, Gomaa A, AbouLaila M, ElKhatam A, Anis A (2023). *Trichomonas gallinae*, prevalence and histopathology in domestic pigeons in Sadat District, Egypt. J. Curr. Vet. Res., 5(1): April 2023. <https://doi.org/10.21608/jcvs.2023.296058>
- Fadhil LT, Faraj AA, Al-Amery AM (2020). *Trichomonas gallinae* identification and histopathological study in pigeon (*Columba liviadomestica*) in Baghdad City, Iraq. Iraqi J. Vet. Med., 44: 57-63. [https://doi.org/10.30539/ijvm.v44i\(E0\).1022](https://doi.org/10.30539/ijvm.v44i(E0).1022)
- Fadhil LT, Faraj AA (2019). Survey of *Trichomonas gallinae* isolates in pigeons by microscopy and PCR. Online J. Vet. Res., 23(4): 321-329.
- Gharavi MJ, Nobakht M, Khademvatan SH, Bandani E, Bakhshayesh M, Roozbehani M (2011). The effect of garlic extract on expression of INF γ and iNOS in macrophages infected with Leishmania major. Iran J. Parasitol., 6(3): 74-81.
- Hamad SS, Hassan HH (2017). Isolation, diagnosis and cultivation of *Trichomonas gallinae* from domestic pigeon in Kirkuk City, Iraq. Int. J. Curr. Res. Aca. Rev., 5(2): 10-18. <https://doi.org/10.20546/ijcrar.2017.502.002>
- Hammadi HA, Naji HA, Al-Aqaby AR (2023). Clinical survey and molecular detection of *Trichomonas gallinae* infection of domestic pigeons (*Columba livia domestica*) in Al-Qadisiyah Province, Iraq. Iraqi J. Vet. Sci., 37(3): 745-750. <https://doi.org/10.3389/ijvs.2023.135093.2451>
- Hanieh H, Kiyooki N, Mingzi P, Chaogetu G, Asaki A, Yasuhiro K (2010). Modulatory effects of two levels of dietary alliums on immune response and certain immunological variables, following immunization, in White Leghorn chickens. Anim. Sci. J., 81(6): 673-680. <https://doi.org/10.1111/j.1740-0929.2010.00798.x>
- Jafar EH, Kawan MH, Jafar NS (2014). Some epidemiological study of *Trichomonas gallinae* in domestic pigeon in Baghdad province. Vet. J., 38(2): 1-4.
- Jawad RA, Al-Ali F, Rashid IF, Al-Sabbagh JK, Sulbi IM, Noor MI, Saber WA (2020). Prevalence comparative study of infection with *Trichomonas* spp. in the three types of birds at the holy city of Kerbala. Indian J. Forensic Med. Toxicol., 14(3).
- Ji F, Zhang D, Shao Y, Yu X, Liu X, Shan D, Wang Z (2020). Changes in the diversity and composition of gut microbiota in pigeon squabs infected with *Trichomonas gallinae*. Sci. Rep., 10: 19978. <https://doi.org/10.1038/s41598-020-76821-9>
- Kocia-Tanackov SD, Gordana R, Aleksandra N, Biserka LV (2009). Influence of *Allium ampeloprasum* L. and *Allium cepa* L. essential oils on the growth of some yeasts and moulds. Proc. Nat. Sci. Matica Srpska Novi Sad., 116: 121-130. <https://doi.org/10.2298/ZMSPN0916121K>
- Lawson B, Cunningham AA, Chantrey J, Hughes LA, John SK, Bunbury N, Bell DJ, Tyler KMA (2011). Clonal strain of *Trichomonas gallinae* is the aetiological agent of an emerging avian epidemic disease. Infect. Genet. Evol., 11: 1638-1645. <https://doi.org/10.1016/j.meegid.2011.06.007>
- McDougald LR, Nair V, Suarez DL, Nolan LK, Glisson JR, Swayne DE (2013). Diseases of poultry. Protozoal Infections: Trichomoniasis. 13th ed. Iowa State University Press, Ames, IA, pp. 1179-1181.
- Mohamed HM, Saad ASA, Khalifa MM, Abdel-Maogood SZ, Awadalla SMF, Mousa WM (2023). Detection and molecular characterization of *Trichomonas gallinae* recovered from domestic pigeons in Egypt. Parasitol. Res., 122(1): 257-263. <https://doi.org/10.1007/s00436-022-07724-z>
- Mousa AJ, Hamid NR (2023). *Trichomonas gallinae* prevalence and genetic characteristics from racing pigeons in Thi-Qar Province, Iraq. Adv. Anim. Vet. Sci., 11(10): 1690. <https://doi.org/10.17582/journal.aavs/2023/11.10.1690.1696>

- Muzeal FA, Khudeir MAA (2022). Pathological lesions of *Trichomonas gallinae* in domestic pigeons (*Columba livia*) of Al-Muthanna province, Iraq. Al-Qadisiyah J. Vet. Med. Sci., 21.
- Raza A, Qamar MF, Rubtsova N, Saneela S (2018). Pathogenicity and diagnostic sensitivity of culture media for identification of *Trichomonas gallinae* in domestic pigeons of Lahore, Pakistan. J. Protozool. Res., 28: 11-21.
- Rehman Z, Munir MT (2015). Effect of garlic on the health and performance of broilers. Veterinaria, 3(1): 32-39.
- Robinson RA, Lawson B, Toms MP, Peck KM, Kirkwood JK, Chantrey J, Clatworthy IR, Evans AD, Hughes LA (2010). Emerging infectious disease leads to rapid population declines of common British birds. PLoS One, 5(8): e12215. <https://doi.org/10.1371/journal.pone.0012215>.
- Sadr S, Ghafouri SA, Ghaniei A, Moharreri DJ, Zeinali M, Qaemifar N, Jafroodi PP, Hajiannezhad Z, Atazade AH (2022). Treatment of avian trichomoniasis by tannin-based herbal mixture (*Artemisia annua*, *Quercus infectoria* and *Allium sativum*). J. World's Poult. Sci., 1(2): 32-39. <https://doi.org/10.58803/JWPS.2022.1.2.01>
- Saikia M, Bhattacharjee K, Sarmah PC, Deka DK, Upadhyaya TN, Konch P (2021). Prevalence and pathology of *Trichomonas gallinae* in domestic pigeon (*Columba livia domestica*) of Assam, India. Indian J. Anim. Res., 55(1): 84-89. <https://doi.org/10.18805/IJAR.B-3805>
- Saleem MH, Khan MS, Chaudry AS, Samad HA (2008). Prevalence of *Trichomoniasis* in domestic and wild pigeon and its effects on hematological parameters. Pak. Vet. J., 28(2): 89-91.
- Samour JH, Naldo JL (2003). Diagnosis and therapeutic management of *Trichomoniasis* in falcons in Saudi Arabia. J. Avian Med. Surg., 17(3): 136-143. <https://doi.org/10.1647/2001-047>
- Schalm OW (1986). Veterinary hematology, 4th edn. Lea and Febiger, Philadelphia, USA.
- Seddiek SA, El-Shorbagy MM, Khater HF, Ali AM (2014). The antitrichomonal efficacy of garlic and metronidazole against *Trichomonas gallinae* infecting domestic pigeons. Original paper, Parasitol. Res., 10(7): 1-6.
- Soulsby EJJ (1986). Helminthes, arthropods and protozoa of domesticated animals. Monnings Vet. and Entomology. 7th Ed. ELBS, London: pp. 562.
- Stoute T, Charlton BR, Bickford AA, Bland MC (2009). Respiratory tract trichomoniasis in breeder squab candidates in Northern California. Avian Dis., 53(1): 139-142. <https://doi.org/10.1637/8389-070108-Case.1>
- Thomas RC (2017). Molecular epidemiology of *Trichomonas gallinae* in European turtle doves (*Streptopelia turtur*). University of Leeds, School of Biology. pp. 294.
- Villanua D, Hofle U, Rodriguez LP, Gortazar C (2006). *Trichomonas gallinae* in wintering common wood pigeons *Columba palumbus* in Ibis, Spain. Int. J. Avian Sci., 148: 641-648. <https://doi.org/10.1111/j.1474-919X.2006.00561.x>
- Xiang C, Li Y, Jing S, Han S, He H (2023). *Trichomonas gallinae* kills host cells using trophocytosis. Pathogens. 12: 1008. <https://doi.org/10.3390/pathogens12081008>