Acta Scientiarum. Biological Sciences
ISSN: 1679-9283
ISSN: 1807-863X
actabiol@uem.br
Universidade Estadual de Maringá
Brasil

Oliveira, Tiago Mendonça de; Teixeira, Cristina Mara; Pinto, Mariana Olímpia Köhler Marra; Arcebispo, Thiago Luiz Mendes; Soriano-Araújo, Amanda; Cunha, Lucas Maciel; Diniz, Soraia Araújo; Silva, Marcos Xavier

Epidemiological characterization and risk evaluation associated with the presence of Phthiraptera in poultry farms from Minas Gerais, Brazil

Acta Scientiarum. Biological Sciences, vol. 41, 2019
Universidade Estadual de Maringá
Brasil

DOI: https://doi.org/10.4025/actascibiolsci.v41i1.47474

Acta Scientiarum
http://periodicos.uem.br/ojs
ISSN on-line: 1807-863X
Doi: 10.4025/actascibiolsci.v41i1.47474

Epidemiological characterization and risk evaluation associated with the presence of Phthiraptera in poultry farms from Minas Gerais, Brazil

Tiago Mendonça de Oliveira[1*], Cristina Mara Teixeira[2], Mariana Olímpia Köhler Marra Pinto[1], Thiago Luiz Mendes Arcebispo[3], Amanda Soriano-Araújo[4], Lucas Maciel Cunha[5], Soraia Araújo Diniz[1] and Marcos Xavier Silva[1]

[1]Escola de Veterinária, Universidade Federal de Minas Gerais, Avenida Presidente Antônio Carlos, 6627, 31270-901, Belo Horizonte, Minas Gerais, Brazil. [2]Ministerio da Agricultura Pecuária e Abastecimento, Brasília, Distrito Federal, Brazil. [3]Ministerio da Agricultura Pecuária e Abastecimento, Rondônia, Acre, Brazil. [4]Instituto Federal de Minas Gerais, Bambuí, Minas Gerais, Brazil. [5]Fundação Ezequiel Dias, Belo Horizonte, Minas Gerais, Brazil. *Author for correspondence. E-mail: tiago0725@gmail.com

ABSTRACT. Phthiraptera are lice highly adapted to living as permanent and obligatory ectoparasites of birds and mammals. High infestations by biting lice contribute to the low productivity, loss quality of the eggs, besides weight decrease of chickens. Therefore, this study aimed to evaluate and to characterize the risks involved with the presence of biting lice in laying chicken from Minas Gerais, Brazil, throught a Multiple Correspondence Analysis (MCA). A secondary database with information regarding 402 chicken houses from 42 properties of laying hens from the same region was used and adapted for this study. The variables that composed the correspondence model were selected through Chi-square tests ($p \leq 0.05$). A risk index was designed to relate the presence of biting lice out of variables such as risk factors related to the presence of these ectoparasites. The MCA graphic designed to conduct the epidemiological characterization of the presence of biting lice presented a Chi-square accumulated value of 53.59%. There was an association between the risk index and the synanthropic birds, subsistence hens, presence of lice and other ectoparasites in shelters and ectoparasites control. These results provide knowledge about the Phthiraptera epidemiology. Besides that, this information may contribute to the decision-making process in order to reduce the risk of possible infestations in poultry farms and the negative effects of the infestations.

Keywords: Epidemiology; Lice; Laying hens; Risk index; Correspondence analysis.

Received on April 11, 2019.
Accepted on September 16, 2019.

Introduction

Phthiraptera order is constituted by invertebrates popularly known as lice. These insects are highly adapted to live as permanent ectoparasites of birds and mammals (Guimarães, Tucci, & Barros-Battesti, 2001; Pereira, 2009; Enout, Lobato, Diniz, & Antonini, 2012). Phthiraptera are permanent and obligatory ectoparasites, in other words, they complete the entire life cycle on the host body (Axtell & Arends, 1990; Johnson & Clayton, 2003). The dispersion of these ectoparasites at laying houses is associated with factors such as the transit of persons, wild birds, fomites and rodents (Axtell & Arends, 1990; Guerra, Chaves, Passos, & Santos, 2008). Some environmental factors may influence the occurrence of these ectoparasites (Kumar & Kumar, 2014). According to Nadeem et al. (2007) the monthly lice infestation prevalence was higher during the summer in Pakistan. Some studies have shown that poultry with trimmed beak shows a high degree of *Menacanthus stramineus* (Nitzsch, 1818) infestation when compared to the chicken that has regular beak (Brown, 1972; Mullens, Chen, & Owen, 2010).

In Brazil, the Phthiraptera infestation in domestic and wild birds has also been reported (Ferreira, Bezerra, & Ahid, 2010; Figueiredo, Guimarães, & Gama, 1993; Oliveira, Ferreira, & Serra-Freire, 1999; Guimarães et al., 2001; Guerra et al., 2008). In the state of Minas Gerais, it was observed the presence of the following species in commercial poultry farms: *M. stramineus*, *M. cornutus* (Schommer, 1913), *M. pallidulus* (Neumann, 1912) and, still, *Lipeurus caponis* (Nitzsch, 1818) (Rezende, Cunha, Martins, Teixeira, & Oliveira,

2015; Rezende, Martins, Teixeira, Oliveira, & Cunha, 2016). In a Brazilian study about these parasites' biology and ecology, Figueiredo et al. (1993) suggested that menoponides high infestations contribute to the low productivity and the quality of the eggs. In India, a study has described the weight loss in chicken infested by biting lice (Panda & Ahluwalia, 1983). Considering the possible economic, productive and sanitary losses by the commercial poultry industry that may be attributed to lice infestation, this study aimed to develop a risk index and to characterize the epidemiology of these ectoparasites in poultry farms from Minas Gerais, Brazil.

Material and methods

Sampling

This work was accomplished from a secondary database analysis and was structured with information about the presence or absence of ectoparasites in laying houses, birds, facilities characteristics, geographic location and handling of 402 laying houses from 42 commercial poultry farms from the state of Minas Gerais, Brazil.

Epidemiological aspects that could characterize the presence of parasites from the Phthiraptera order in those laying houses were evaluated through the use of the Multiple Correspondence Analysis (MCA). The variables presented in the database were dichotomized or categorized in order to the analysis accomplishment. The selection of the evaluated farms and the sample stratification were performed considering the proportion of industrial poultry farms from each Coordinating Regional of the *Instituto Mineiro de Agropecuária* (IMA), respecting the confidentiality of each location.

Risk index

A risk index presenting 11 variables that were considered as "risk" according to those described by Rezende et al. (2015) and Rezende et al. (2016) was used in order to characterize the presence of these parasites (Table 1). The presence or the absence of these variables were used for the design of the risk index, with a scoring assignment, being the risk variables indicated as (Importance 1) and protection as (Importance 0), then it was applied to the 402 laying houses of the study. This index was divided into three categories according to the score obtained by the analysis, being the low risk scored by 1 to 4 points, moderate risk by 5 to 7 and high risk above 8. Besides that, the variables that presented three categories, such as the age of the birds, the score was related to the risk that each category (age range) represented to the biting lice presence at laying houses. From that result it was possible to classify the risk for the presence of these ectoparasites in the MCA.

Table 1. Variables used for the development of the risk index for the presence of Phthiraptera in laying houses from the state of Minas Gerais, Brazil.

Variables used in the risk index development
Lodging kind (floor or cage)
Use or not-use of selective insecticide
Use or not-use of grille surrounding the sheds
Use or not-use of acaricide for the hematophagous mites
Presence or absence of *Columba livia* (Gmelin, 1789) in the surroundings of the laying houses Presence or absence of *Bubulcus ibis* (Linnaeus, 1758) in the surroundings of the laying houses
Presence or absence of *Gnorimopsar chopi* (Vieillot, 1819) in the surroundings of the laying houses
Presence or absence of subsistence hens on the shed's surroundings
Presence or absence of *Sicalis flaveola* (Linnaeus, 1766) in the surroundings of the laying houses
Presence or absence of *Guira guira* (Gmelin, 1788) and *Crotophaga ani* Linnaeus, 1758 in the surroundings of the laying houses
Age of the birds 1 (98 – 382 days), 2 (383 – 667 days) and 3 (668 - 1047 days)

Statistical analysis

The variables that might be eligible to compose the correspondence model were selected by Pearson's Chi-square test ($p \leqslant 0.05$) (Table 2) and were submitted to the MCA in order to be evaluated according to the possible associations between the presence of Phthiraptera and the risk index through graphic figures.

The graphic evaluation and the interpretation were obtained as the proximity of the variables to the risk index was examined. The intensity of the association with accumulated inertia values above 40% reached by

the analysis was also considered (Mingoti, 2005; Fávero & Belfiore, 2015). The software Stata®/SE 12.0 (Statacorp, 2012) was used for the variables screening and the design of the three axes correspondence graphic.

Table 2. Frequency of lice in laying houses in the state of Minas Gerais, Brazil.

Ectoparasites	Number of laying houses with a positive diagnosis	Frequency (%)
Phthiraptera	83	21.0
Menacanthus cornutus	42	10.0
Menacanthus stramineus	34	8.0
Menacanthus pallidulus	13	3.2
Lipeurus caponis	4	1.0

Georeferencing

A spatial analysis study regarding the presence of Phthiraptera was carried out with the objective of demonstrating the intensity of infestations in laying houses through a Kernel map. For this, the software QGIS (2016) was used and made it possible to georeference locations that presented laying houses with biting lice in Minas Gerais, Brazil.

Results

The frequency of biting lice in laying houses in the state of Minas Gerais is presented on Table 2. The taxon Phthiraptera was present in 83 laying houses, being the genus *Menacanthus* the most common.

The MCA graphic designed in order to characterize the presence of lice in poultry farms presented the accumulated chi-square value of 53.59% (Figure 1). The evaluated graphic variables are inserted in the blue circles and their respective legends and abbreviations are in Table 3.

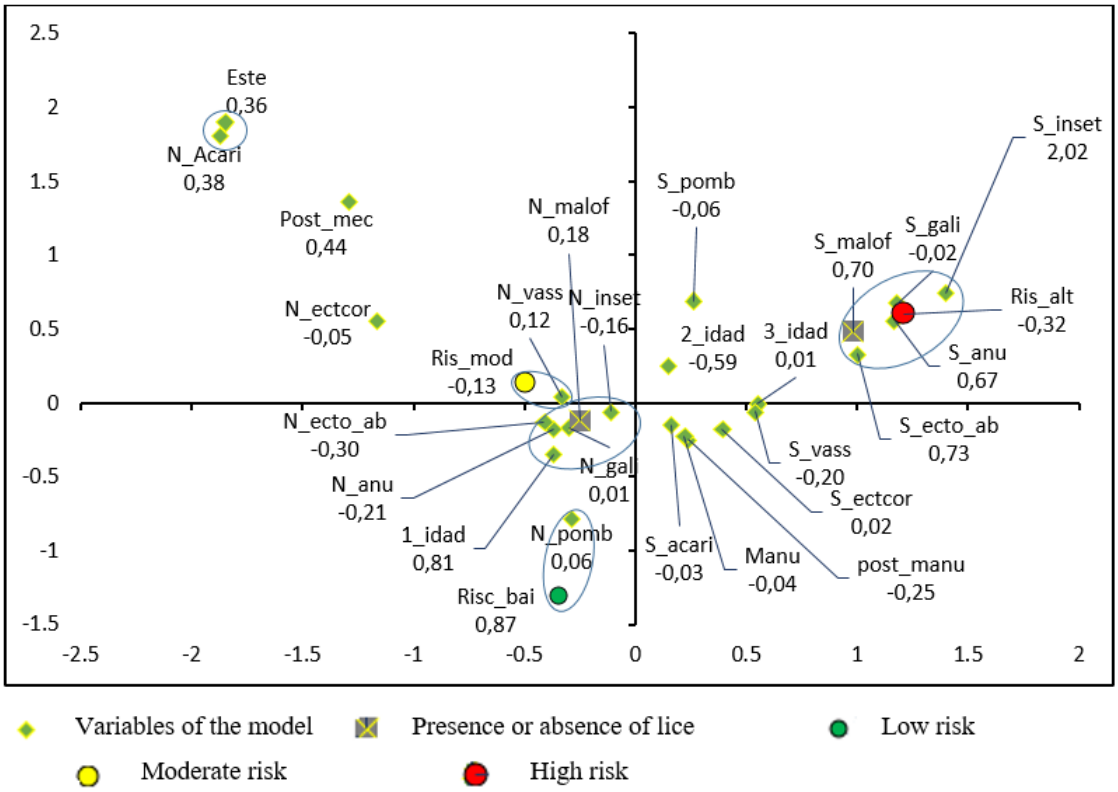

Figure 1. Correspondence analysis graphic of the epidemiological characterization of the biting lice in laying houses from Minas Gerais, Brazil.

The other variables associated with the biting lice absence were the non-use of a selective insecticide, the absence of synanthropic birds, ectoparasites in the shelter and with birds age 1 (98 – 382 days). It is important to report that in these variables absence these parasites' presence would not occur.

Table 3. Subtitles for the variables of the correspondence analysis graphic for Phthiraptera.

Variables	Abbreviation
Type of creation (laying with manual egg collection)	Pos_man
Type of creation (laying with mechanical egg collection)	Pos_mec
Manual waste removal	Manu
Treadmill waste removal	Este
Laying hens age 1 (98 – 382 days)	1_idad
Laying hens age 2 (383 – 667 days)	2_idad
Laying hens age 3 (668 – 1047 days)	3_idad
Non-use of acaricide in the laying houses	N_acid
Use of acaricide in the laying houses	S_acid
Non-use of selective insecticides in laying houses	N_inset
Use of selective insecticides in the laying houses	S_inset
Use of the fire broom (flamethrower) in the poultry facilities	S_vass
Non-use of the fire broom (flamethrower) in the poultry facilities	N_vass
Absence of *C. livia* on the laying houses surroundings	N_pomb
Presence of *C. livia* on the laying houses surroundings	S_pomb
Absence of *G. guira* and *C. ani* on the laying houses surroundings	N_anu
Presence of *G. guira* and *C. ani* on the laying houses surroundings	S_anu
Absence of subsistence hens on the laying houses surroundings	N_gali
Presence of subsistence hens on the laying houses surroundings	S_gali
Absence of ectoparasites on the laying hens body	N_ectcor
Presence of ectoparasites on the laying hens body	S_ectcor
Absence of ectoparasites in the laying houses shelters	N_ect_ab
Presence of ectoparasites in the laying houses shelters	S_ect_ab
Absence of Phthiraptera in the poultry facilities (lice)	N_malof
Presence of Phthiraptera in the poultry facilities (lice)	S_malof
Low-risk for the presence of ectoparasites	Ris_bai
Moderate-risk for the presence of ectoparasites	Ris_mod
High-risk for the presence of ectoparasites	Ris_alt

It was observed that the presence of synanthropic birds, such as *G. guira* and *C. ani*, domestic chicken near the laying houses, presence of biting lice and other ectoparasites in the shelters were associated with the high-risk index. The moderate-risk index for the presence of Phthiraptera was associated with the non-use of the fire broom (flamethrower) in the shed facilities. The low-risk index was associated with the absence of *C. livia*.

A strong association between the laying houses mechanical infrastructure and the chemical control by acaricide was observed. More technician poultry farms do not use acaricide in their facilities.

The locations of the sheds detected with biting lice are represented in the Figure 2. It is possible to observe that there are few clustered points in the mesoregion south/southeast of Minas Gerais and in the Belo Horizonte metropolitan mesoregion.

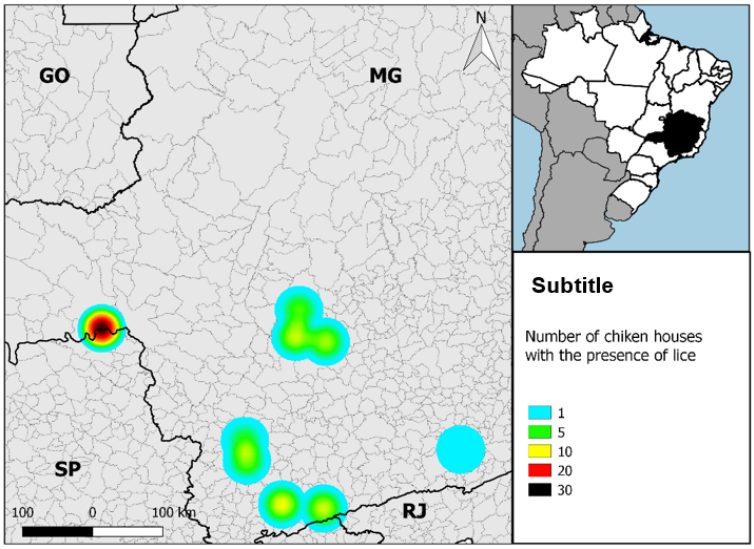

Figure 2. Map of the locations that presented laying houses with Phthiraptera in Minas Gerais, Brazil, 2012.

Discussion

The observed frequency of biting lice in this study is partially similar to other surveys (Ferreira et al., 2010; Figueiredo et al., 1993; Guerra, et al., 2008; Santos, Santos, Aguiar, Ruas, & Farias, 2013; Rezende et al., 2015; Rezende et al., 2016). Synanthropic birds might be lice mechanical vectors, in accordance with Axtell and Arends (1990), who described the lice insertion and dissemination by this type of birds, rodents, equipments and people's movement. Moreover, other research performed by Rezende et al. (2015) observed that *C. ani* in the farm's vicinity was a predisposing factor for these ectoparasites occurrence because it presented a prevalence ratio with the confidence interval greater than one, what made it possible to rank it on this risk category. However, new studies that involve the carrying behavior need to be conducted in order to evaluate the lice dispersion by synanthropic birds inside the laying houses.

The presence of synanthropic birds near the laying houses is classified as a risk. This result corroborates with other descriptions that assert the biting lice dispersion when in the presence of these infested synanthropic birds (Devaney, Quisenberry, Doran, & Bradley, 1980; Axtell & Arends, 1990). The pigeon's presence close to the laying houses is a predisposing factor for the occurrence of *M. cornutus* and, thus, the absence of these birds in the sheds surroundings is considered as low-risk for the biting lice presence (Rezende et al., 2016).

The close contact to the subsistence hens may contribute to the occurrence of this ectoparasite group in laying hens' sheds, since this factor is considered as a risk one, as observed in other studies (Rezende et al., 2015; Rezende et al., 2016).

It was verified that the presence of lice was associated with the presence of other ectoparasites in the shelters and that fact might be justified by the great diversity of parasites and non-parasites arthropods inside the laying houses. Therefore, simultaneous infestations by ectoparasites that are able to remain at the same environment was possible to be observed. The presence of other ectoparasites might be an indicator that the poultry farms do not adopt controlling measures against them, or if they do, it is conducted in a precarious way and such practices might contribute to possible resistance to pesticides (Nadeem et al., 2007; Benelli, Caselli, Di Giuseppe, & Canale, 2018).

The non-use of fire broom inside the laying houses is classified as moderate risk. This fact may occur due to the presence of some lice inside the laying houses or even due to dispersion caused by the movement of people, the presence of synanthropic birds, rodents and contaminated fomites. The use of objects to distribute food to the feeders or the presence of synanthropic birds justifies the importance of flamethrower in the poultry farms. When there are not controlling measures, the lice longevity tends to increase, what might compromise the birds' health (Pinto et al., 2001). On the other hand, Figueiredo et al. (1993) described that the use of fire broom is not able itself to control these ectoparasites on birds, due to the lice habit of living and reproducing on the birds body and feathers and not in the laying houses facilities.

More technified poultry farms do not use acaricide, because in those places the waste removal and the egg collection are made by mechanical treadmills, that is, it decreases the movement of people inside the laying houses, what might reflect in a low-risk for the occurrence of lice. Similar results were observed by Oliveira et al. (2017) and Oliveira et al. (2018), in which more technical laying houses did not use acaricides to control hematophagous mites. These chemical products are not used for the lice control, however Rezende et al. (2016) observed that the recent use of acaricide was a protection factor for the occurrence of *M. cornutus*. These authors also suggest that these acaricides active principles exercise an effect against this lice species.

It is suggested that lice absence associated with the birds age 1 may be attributed to the exposure time to these ectoparasites infestation risk factors, that is, it is expected that older birds might be predisposed to the infestations when compared to younger birds. The odds of the *M. stramineus* infestation occurrence are increased 1,007 times each survival day of birds, that is, the older the birds are the bigger are the odds of this parasite occurrence (Rezende et al., 2016). Besides that, other factor may contribute to the infestation on older birds, such as the lice inappropriate control. In Pakistan, Nadeem et al. (2007) observed a higher occurrence of Phthiraptera on birds aged between 36 and 72 weeks due to the regular use of insecticides among different aged birds groups.

It is suggested that the few clustered points in the mesoregion south/southeast of Minas Gerais and in the Belo Horizonte metropolitan mesoregion is due to the diversity of climatic conditions among the georeferenced locations. Some places are warmer and have lower relative humidity, while others record

higher pluviometry indexes with a moderate climate. The temperature and humidity are characteristics that may influence the biting lice development (Halbritter & Mullens, 2011). For Chen and Mullens (2008), relative air humidity ranging from 31 to 85% did not affect the survival of nymphs and adults of *M. stramineus*. Halbritter and Mullens (2011) verified that the *Menacanthus* genus needs the temperature above 30ºC for its development. For Arundel and Sutherland (1988), the fluctuation in Mallophaga populations is related to the high summer temperatures, solar radiation, heavy rainfall and to sharing of livestock animals. In a study performed in India (Kumar & Kumar, 2014), it was verified that the high temperature and an humid climate were favorable to the *M. cornutus* population fluctuation. Thus, this could justify the lower or higher intensity of these ectoparasites present in certain locations from the state. Still, it is important to highlight that the possible influence of risk factors in these locations farms, such as the lack of mechanization, sanitary barriers, improper handling, an excessive number of birds per cage and the lodging kind, may also favor the presence of lice in different poultry farms from Minas Gerais.

Conclusion

Laying houses' environmental conditions and handling characteristics may influence the lice infestation epidemiological aspects. The presence of synanthropic birds as *G. guira* and *C. ani* and subsistence hens are high-risk factors for the presence of Phthiraptera. The execution of certain handling measures and the technification investment in the laying houses might reduce the risk for the presence of ectoparasites and, thereafter, reduce the use of pesticides and the possible risks for their residues on eggs.

The use of flamethrower in the poultry facilities is a controlling strategy in other sanitary events such as those related to viruses and bacteria. However, this practice might have some influence on the presence of Phthiraptera, since it is observed through the correspondence graphic that when it is not performed the risk for the occurrence of these ectoparasites is moderate.

The development of the risk index evidences the profile of the poultry farms that presented Phthiraptera in their laying houses. Besides, the knowledge of these characteristics might contribute to decision-making in order to decrease the possible risks for infestation on laying poultry and its negative effects. This index can also be used for the development of integrating handling programs against harmful ectoparasites of poultry farms from the state of Minas Gerais, Brazil.

Acknowlegements

We appreciate the financial support and scholarships provided by *Fundação de Amparo à Pesquisa do Estado de Minas Gerais* (FAPEMIG), of *Coordenação de Aperfeiçoamento de Pessoal de Nível Superior* (CAPES) and by *Conselho Nacional de Desenvolvimento Científico e Tecnológico* (CNPq).

References

Arundel, J. H., & Sutherland, A. K. (1988). *Animal health in Australia: ectoparasitic diseases of sheep, cattle, goats and horses.* Canberra, AU: Australian Government Publishing Service.

Axtell, R. C., & Arends, J. J. (1990). Ecology and management of arthropod pests of poultry. *Annual Review of Entomology, 35*, 101-126. doi: 10.1146/annurev.en.35.010190.000533

Benelli, G., Caselli, A., Di Giuseppe, G., & Canale, A. (2018). Control of biting lice, Mallophaga – a review. *Acta Tropica, 177*, 211-219. doi: 10.1016/j.actatropica.2017.05.031

Brown, N. S. (1972). The effect of host beak condition on the size of *Menacanthus stramineus* populations of domestic chickens. *Poultry Science, 51*(1), 162-164. doi: 10.3382/ps.0510162

Chen, B. L., & Mullens, B. A. (2008). Temperature and humidity effects on off-host survival of the Northern fowl mite (Acari: Macronyssidae) and the chicken body louse (Phthiraptera: Menoponidae). *Journal of Economic Entomology, 101*(2), 637-646. doi: 10.1603/0022-0493(2008)101[637:taheoo]2.0.co;2

Devaney, J. A., Quisenberry, J. H., Doran, B. H., & Bradley, J. W. (1980). Dispersal of the northern fowl mite, *Ornithonyssus sylviarum* (Canestrini and Fanzago), and the chicken body louse, *Menacanthus stramineus* (Nitzsch), among thirty strains of egg-type hens in a caged laying house. *Poultry Science, 59*(8), 1745-1749. doi: 10.3382/ps.0591745

Enout, A. M. J., Lobato, D. N. C., Diniz, F. C., & Antonini, Y. (2012). Chewing lice (Insecta, Phthiraptera) and feather mites (Acari, Astigmata) associated with birds of the Cerrado in Central Brazil. *Parasitology Research, 111*(4), 1731-1742. doi: 10.1007/s00436-012-3016-5

Fávero, L. P., & Belfiore, P. (2015). Análise de dados - técnicas multivariadas exploratórias com Spss e Stata. In L. P. Fávero & P. Belfiore (Eds.), *Análise de Correspondência Simples e Múltipla* (p. 177-265). Rio de Janeiro: Elsevier.

Ferreira, C. G. T., Bezerra, A. C. D. S, & Ahid, S. M. M. (2010). Inquérito ectoparasitológico em galinhas caipiras, *Gallus gallus domesticus*, do município de Apodi, Rio Grande do Norte, Brasil. *Revista Brasileira de Zoociências, 12*(3), 249-256.

Figueiredo, S. M., Guimarães, J. H., & Gama, N. M. S. Q. (1993). Biologia e ecologia de malófagos (Insecta: Phthiraptera) em aves de postura de granjas industriais. *Revista Brasileira de Parasitologia Veterinária, 2*(1), 45-51.

QGIS. (2016). *Geographic Information System 2.18.1* (Open Source Geospatial Foundation Project) [Software]. Retrieved on October 20, 2016 from: https://www.qgis.org/pt_BR/site/index.html

Guerra, R. M. S. N. C., Chaves, E. P., Passos, T. M. G., & Santos, A. C. G. (2008). Species, dynamics and population composition of phthirapteran in free-range chickens (*Gallus gallus* L.) in São Luis Island, State of Maranhão. *Neotropical Entomology, 37*(3), 259-264. doi: 10.1590/S1519-566X2008000300004

Guimarães, J. H., Tucci, E. C., & Barros-Battesti, D. M. (2001). *Ectoparasitos de importância veterinária*. São Paulo, SP: Fapesp.

Halbritter, D. A., & Mullens, B. A. (2011). Responses of *Ornithonyssus sylviarum* (Acari: Macronyssidae) and *Menacanthus stramineus* (Phthiraptera: Menoponidae) to gradientes of temperature, light, and humidity, with comments on microhabitat selection on chickens. *Journal of Medical Entomology, 48*(2), 251-261. doi: 10.1603/ME10198

Johnson, K. P., & Clayton, D. H. (2003). Coevolutionary history of ecological replicates: comparing phylogenies of wing and body lice to *Columbiform* hosts. In R. D. M. Page (Ed.), *Tangled trees: phylogeny, cospeciation, and coevolution* (p. 262-286). Chicago, IL: University of Chicago Press.

Kumar, A., & Kumar, R. (2014). Seasonal changes in the population of *Menacanthus cornutus* (Phthiraptera: Amblycera). *Journal of Parasitic Diseases, 38*(3), 307-310. doi: 10.1007/s12639-013-0249-x

Mingoti, S. A. (2005). Análise de dados através de métodos de estatística multivariada – uma abordagem aplicada. Belo Horizonte, MG: UFMG.

Mullens, B. A., Chen B. L., & Owen, J. P. (2010). Beak condition and cage density determine abundance and spatial distribution of northern fowl mites, *Ornithonyssus sylviarum*, and chicken body lice, *Menacanthus stramineus*, on caged laying hens. *Poultry Science, 89*(12), 2565-2572. doi: 10.3382/ps.2010-00955

Nadeem, M., Khan, M. N., Iqbal, Z., Sajid, M. S., Arshad, M., & Yaseen, M. (2007). Determinants influencing prevalence of louse infestations on layers of district Faisalabad (Pakistan). *British Poultry Science, 48*(5), 546-550. doi: 10.1080/00071660701573086

Oliveira, H. H., Ferreira I., & Serra-Freire, N. M. (1999). Fauna de Mallophaga (Insecta: Aptera) de ectoparasitos em *Gallus gallus* L. e *Columba livia* L. amostrados no Rio de Janeiro - Brasil. *Entomología y Vectores, 6*(5), 509-515.

Oliveira, T. M., Teixeira, C. M., Arcebispo, T. L. M., Antunes, K. D., Rezende, L. C., Cunha, L. M., ... Silva, M. X. (2017). Epidemiological characterization and risk evaluation associated with the presence of *Megninia* spp. in posture farms. *Ciência Rural, 47*(9). doi: 10.1590/0103-8478cr20170186

Oliveira, T. M., Teixeira, C. M., Araujo, I. L., Rezende, L. C., Cunha, L. M., Castro-Filho, R. P. L., ... Silva, M. X. (2018). Caracterização epidemiológica e avaliação de risco associados à presença da ordem Diptera em granjas de postura. *Acta Scientiae Veterinariae, 46*(1), 1563. doi: 10.22456/1679-9216.83468

Panda, D. N., & Ahluwalia, S. S. (1983). Effect of *Menacanthus stramineus* and *Lipeurus tropicalis* infestation on weight gains in broiler birds. *Indian Veterinary Journal, 60*, 85-87.

Pereira, M. C. (2009). Ectoparasitose. In L. Revolledo & A. J. P. Ferreira (Ed.), *Patologia Aviária* (p. 327-329). Barueri: Manole.

Pinto, C., Possati, M., Villaça, A., Guerim, L., Sá-Freire, L., & Serra-Freire, N. M. (2001). Ocorrência de malófagos em galinhas caipiras e sua relação com o padrão de coloração da plumagem. *Entomologia y Vectores, 8*, 295-301.

Rezende, L. C., Cunha, L. M., Martins, N. R. S., Teixeira, C. M., & Oliveira, P. R. (2015). Epidemiologia de *Lipeurus caponis* (Phthiraptera: Philopteridae) (Nitzsch, 1818) em granjas avícolas comerciais de postura no estado de Minas Gerais, Brasil. *Revista Brasileira de Ciência Veterinária, 22*(1), 34-38. doi: 10.4322/rbcv.2015.316

Rezende, L. C., Martins, N. R. S., Teixeira, C. M., Oliveira, P. R., & Cunha, L. M. (2016). Epidemiological aspects of lice (*Menacanthus* species) infections in laying hen flocks from the state of Minas Gerais, Brazil. *British Poultry Science*, *57*(1), 44-50. doi: 10.1080/00071668.2015.1127893

Santos, L. S. S., Santos, L. M. J. F., Aguiar, C. L. G., Ruas, J. L., & Farias, N. A. R. (2013). Parasitism of *Gallus gallus* (Linnaeus, 1758) by species of Phthiraptera on free-range chickens in the southern region of Rio Grande do Sul, Brazil. *Arquivo do Instituto Biológico, 80*(2), 217-221. doi: 10.1590/S1808-16572013000200011

Statacorp. (2012). *Software Stata®/SE 12.0.* College Station, TX: StataCorp.