



Research Article

New Record of Chewing Lice (Phthiraptera: Insecta) on Guinea Fowls (Aves: Galliformes) from Sindh, Pakistan

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Abstract | The chewing lice (Phthiraptera: Insecta) are parasitic insects of variety of birds belonging to the large family of Phasianidae (Aves: Galliformes). The lice have strong mandibles with biting mouth parts and develop specific host-parasite relationship. They cause acute to chronic infestation to hosts directly. These parasitic insects are the source of various diseases, like flue, and also serve as a vector of some bacteria and helminthes parasites. Presently only one type of host, guinea fowl *Numida meleagris* (Linnaeus, 1758) was selected and examined for parasites examination, investigation, identification, population density, means and rate of infestation of from different urban and rural localities of Sindh, Pakistan. There were 15 guinea fowl *Numida meleagris* (Linnaeus, 1758) were captured and brought to the Parasitological laboratory of Department of Zoology, University of Sindh, Jamshoro. The study was carried out from April 2015 –March 2016. Guinea fowls *Numida meleagris* (Linnaeus, 1758) were sprayed with Permethrin (Coopex powder) and ket on white paper sheets for about 32–35 minutes. The fowls were checked time to time after 2 to 3 weeks. The chewing lice were collected hand picking methods with fine brushes and preserved in 70–75% ethyl alcohol. The permanent microscopic slides with cover slips were prepared for final mounting in Canada balsam. At present 130 specimens were recovered and classified into 4 species which belongs to 3 genera. The species and their prevalence are 19.23% for *Menopon gallinae* (Linnaeus, 1758), 23.84% for *Menacanthus stramineus* (Nitzsch, 1818), and 22.30% for *Menacanthus abdominalis* (Piaget, 1880) which belongs to the family Menoponidae and 34.61% for *Goniocotes gallinae* (de Geer, 1776) which belongs to the family Philopteridae. All four species were reported first time as new host and new locality records from the study area. All species of chewing were described and compared with other related species and developed taxonomic key.

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Keywords | Chewing lice, Guinea fowl, Menoponidae, Phthiraptera, Philopteridae, Prevalence, Taxonomy, Pakistan



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1. Introduction

The family Phasianidae (Phthiraptera: Insecta) is one of the largest family of galliform birds (Aves:

Galliformes). The birds are terrestrial, small to large size and often called gallinaceous birds. One of the bird guinea fowl *Numida meleagris* (Linnaeus, 1758) is small size resident domestic fowl of province of

Sindh, Pakistan. It is poultry bird and man usually kept them in their houses for production of eggs. The guinea fowl *Numida meleagris* (Linnaeus, 1758) is easily parasitized by parasitic insects chewing lice and causes infestation and become a source of infection to man. The fowl commonly feeds on small arthropods and control ticks, flies, locusts and scorpions population. The chewing lice (Insecta: Phthiraptera) are biting and obligatory parasites of many birds and mammals. They have no free-living stage in their life cycle. No intermediate host is required and for the completion of life cycle. The chewing lice have exaggerated head with large mandibles. There are more than 450 species of chewing lice parasitizing gallinaceous birds (Price *et al.*, 2003). The chewing lice develop mutual symbiotic association with their host. If we separate them the death rate of lice was observed (Nelson and Murry, 1971). The entire life of chewing lice is committed to parasitism. They require the host body for food, shelter, protection, multiplication and for reproduction (Clayton, 1991). The study on identification and classification of Mallophaga (Phthiraptera: Insecta) is still continue (Lyal, 1985; Johnson and Whiting, 2002). The chewing lice principally are classified into four Suborders: Anoplura, Ryncophthirina, Amblycera and Ischnocera (Cruickshank *et al.*, 2001). The two suborders amblycera and ischnocera parasitizing birds only. The structural characteristics of amblycera follows, slow to fast moving on the head and neck region on fowls, have rounded bodies and large heads with large mandible (Askew, 1971). Mouth parts are opposable which move in perpendicular plane and articulated to the ventral surface of head (Clay, 1949; Nelson, 1972). The neck has two visible segments mesothorax and metathorax. The structural characteristics of ischnocera follows, are susceptible to preening, flattened, elongated and remain attached to the body of the hosts all time (Smith, 2001). The head is prominent, mouthparts move in parallel plane (Kellogg, 1896; Snodgrass, 1905; Cummings, 1913; 1916). The two visible segments of thorax are combined together to form only one segment called pterothorax. There are usually 11 segments of abdomen. The complete shape of the body is maintained by abdominal segments. The chewing lice are significant economically as they serve as most important pest and infest the domestic fowls and poultry industry. The most frequent infested birds include domestic fowls, chickens, Turkeys fowls, pigeons, sparrows, doves, ducks, etc. and also

other animals include dogs, cats, cattle, horses, etc. (Kettle and Pearce, 1974; De Vaney, 1976; Nelson *et al.*, 1977; Arends, 1997). The suborder amblycera are classified into seven families: Menoponidae, Laemobotheriidae, Ricinidae, Abrocomophagidae, Boopiidae, Gyropidae, and Trimenoponidae, in which first three parasitizing birds and causes infestation. The suborder ischnocera are classified into three families: Philopteridae, Heptapsogasteridae and *Trichophilopteridae* first two parasitizing birds, except one, *Trichophilopteridae*, only parasitize Primates (Mammalia). The gallinaceous birds are the major part of poultry industry, include domestic fowls, chickens, partridges and quails (Batairs), pea fowls and guinea fowls are second source protein and meat production in the world. The research was based on investigation, collection, observation, identification, prevalence, population density and rate of infestation of lice on host body Guinea fowl *Numida meleagris* (Linnaeus, 1758) in the Sindh, region Pakistan. This was first attempt of such morphological and ecological studies of chewing lice in Sindh, Pakistan. The recognition of valuable information will finally help in preventing and managing the transmission of variety of diseases and their causative agents. The identification and completion of their life cycle contribute the knowledge of chewing lice fauna in the region (Ansari, 1944; Brown, 1974; Abebe *et al.*, 1997; Ilves *et al.*, 2013; Audi and Asmau, 2014). The distribution and identification of chewing lice of Indo-Pak regions were followed by (Lakshminarayana, 1979; Naz *et al.*, 2010).

2. Materials and Methods

A total of 15 guinea fowl *Numida meleagris* (Linnaeus, 1758) were captured and observed for chewing lice population. The study was conducted from April 2015 to March 2016 from different urban and rural regions of Sindh, includes Hyderabad, Karachi, Larkana, Badin, Thatta and Mirpur khas located in Province Sindh, Pakistan. The guinea fowl *Numida meleagris* (Linnaeus, 1758) were investigated from their natural environment and brought to the Parasitology laboratory of Department of Zoology, University of Sindh, Jamshoro. Each fowl was sprinkled with Permethrin (Coopex powder) and kept on white paper sheet for about 32-35 minutes. The fowls were examined carefully with fine brushes dipped with 70% to 75% alcohol. The method is called hand picking method. Every specimen was preserved in small vials containing 70-75% ethyl alcohol. The infested fowls

checked time to time 2 to 3 weeks. The permanent microscopic slides were prepared by following standard methods. First step was maceration in KOH for overnight, second step was neutralization in dilute acetic acid for few minutes, third step was cleaning with pressing, fourth step was dehydration of lice from 10% 10 100% ethyl alcohol, fifth step was cleaning of lice with clove oil, six step was fixing with xylol and finally mounting in Canada balsam. The drawings were made by microscope of drawing tube attachment. All measurements were taken by using ocular micrometer and measurements were taken in millimeters and identified by the following abbreviations, like TL total body length, HL head length, POW preocular width, TW temporal width, PL prothorex length, PW prothorax width ML metathorax length MW metathorax length AL abdominal length GL genitalia length and GW genitalia width. Measurements include prevalence and mean deviation and ranges (Palma, 1978; Price *et al.*, 2003).

3. Results and Discussion

A total of 15 guinea fowls were captured and investigated for chewing lice population. About 130 specimens were collected, examined and identified from guinea fowl *Numida meleagris* (Linnaeus, 1758). The collected specimens were classified into 4 species which belongs to 3 genera. It includes genera *Menacanthus* and *Menopon* of the family Menoponidae and the genus *Goniocotes* of the family Philopteridae. Out of 4 species of chewing lice only two species first time were reported from the guinea fowl *Numida meleagris* (Linnaeus, 1758) not only from the Sindh region but also in the World (Price *et al.*, 2003). The two species includes *Menacanthus abdominalis* (Piaget, 1880), and *Goniocotes gallinae* (de Geer, 1776) The research work was conducted in different urban and rural localities of Sindh, includes Hyderabad, Karachi, Larkana, Badin, Thatta and Mirpur Khas from Sindh, Pakistan. The calculation and prevalence of 04 species of lice was made in (Table 1 and Figure 1) on guinea fowl *Numida meleagris* (Linnaeus, 1758) and then their main taxonomic characters were described along with their measuring body parts (Table 2) from the study area.

3.1 *Menacanthus abdominalis* (Piaget, 1880)

Type host: *Coturnix coturnix* (Linnaeus, 1758)

It was dark yellow medium sized chewing lice. It was fast moving has strong and heavy body and belong to

the family Menoponidae (Figure 2). During present investigation 29 specimen of *Menacanthus abdominalis* (Piaget, 1880) were recovered. The prevalence was calculated 22.30% on the host bird. It was recorded first time as a new host and new locality record from guinea fowl *Numida meleagris* (Linnaeus, 1758) from Sindh, Pakistan. Body usually oval to round, the anterior margin of head was not convex; presence of 0.07mm long postpalpal process 0.07; presence complet scleroized gular plate; prosternal evidence of posterior plate having pointed process; presence of two anterior metanotum setae; presence of small postspiracular setae on tergites II-III and VII; genital characteristics were typical to the species; evidence of selender like anal fringe; evidence of large sized basal apodeme; presence of fine genital sclerite which were in pieces shaped.

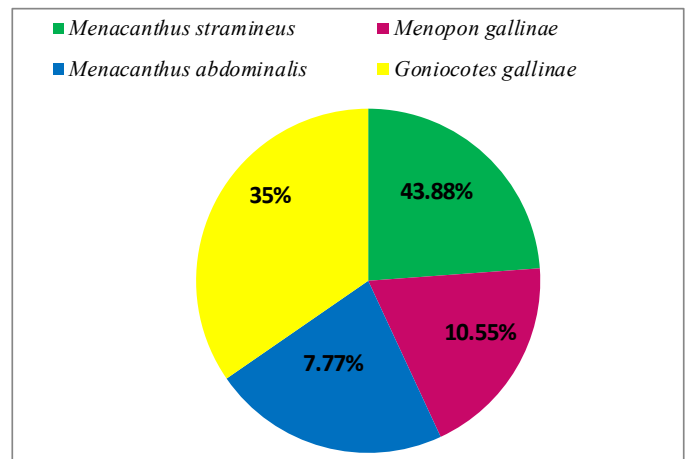


Figure 1: Prevalence of chewing on guinea fowl *Numida meleagris* (Linnaeus, 1758) from study area.



Figure 2: *Menacanthus abdominalis*.

Table 1: The chewing lice of Guinea fowl *Numida meleagris*, (Linnaeus, 1758) collected during 2015–April to 2016– March from six localities of Sindh, Pakistan.

Localities	Total no. of bird examined	<i>Menopon gallinae</i>	<i>Menacanthus stramineus</i>	<i>Menacanthus abdominalis</i>	<i>Goniocotes gallinae</i>
Hyderabad	02	5	07	04	09
Karachi	03	5	06	06	10
Larkana	03	4	05	06	8
Badin	03	4	05	03	5
Thatta	02	3	04	04	6
Mirpur khas	02	4	04	06	7
Total no. of birds and lice specimen	15	25	31	29	45

Table 2: Measurements of body parts of all four type of species in mm (n=3).

Body parts	<i>Menopon gallinae</i>	<i>Mena-canthus stramineus</i>	<i>Menacan-thus ab-dominalis</i>	<i>Goniocotes gallinae</i>
TL	1.646	2.894	2.0	1.40
HL	0.284	0.366	0.30	0.37
POW	0.364	0.534	0.49	0.349
TW	0.479	0.671	0.61	0.44
PL	0.169	0.276	0.20	0.924
PW	0.359	0.541	0.494	0.294
ML	0.114	0.191	0.10	0.159
MW	0.539	0.589	0.589	0.449
AL	1.016	1.914	1.364	0.77
GL	0.336	0.699	-	-
GW	0.070	0.254	-	-

TL: Total length; HL: Head length; POW: Preocular width; TW: Temporal width; PL: Prothorax length; PW: Prothorax width; ML: Metathorax length; MW: Metathorax width; AL: Abdominal length; GL: Genital length; GW: Genital width.

3.2 Material examined

29 ♀, lying on guinea fowl *Numida maleagris* (Linnaeus 1758), habitat include gular region, under wing feathers, breast, belly and leg. Province, Sindh, Pakistan, 2015–April to 2016–March.

3.3 *Menacanthus stramineus* (Nitzsch, 1818)

Type host: *Meleagris gallopavo domestica* Linnaeus, 1758

It was dark yellow large size chewing lice. It was usually fast moving and belongs to the family Menoponidae. It is generally called body louse (Figure 3). During present study 31 specimen of *Menacanthus stramineus* (Nitzsch, 1818) were collected and examined for the first time as a new host and new locality record from guinea fowl *Numida maleagris* (Linnaeus, 1758) Sindh, Pakistan. The prevalence of species was 23.84% on host body. The body was generally diamond shape,

presence of anterior head margin circumfasciate and convex; evidence of postpalpal process which were smaller than 0.07 mm; presence of complete and thin gular plate; presence of convex subsequent margin on prosternal plate; presence of scattered small setae on metanotum; presence of small post spiracular setae on tergites II–VIII; fringe of anal thick; genital characteristics were typical to the species; presence of broad and enlarge apodeme; evidence of branch shaped genital sclerite.



Figure 3: *Menacanthus stramineus*.

3.4 Material examined

19 ♂, 12 ♀, lying on guinea fowl *Numida maleagris* (Linnaeus 1758), habitat include gular region, under wing feathers, belly, breast and leg. Province Sindh, Pakistan, 2015– April to 2016–March.

3.5 *Menopon gallinae* (Linnaeus, 1758)

Type host: *Gallus gallus domesticus* Linnaeus, 1758

It was pale yellow small size shaft louse. It was usually active and belongs to the family Menoponidae

(Figure 4). During present investigation 25 specimen of *Menopon gallinae* (Linnaeus, 1758) were collected first time as a new host and new locality record from the guinea fowl *Numida maleagris* (Linnaeus, 1758) Sindh, Pakistan. The prevalence of species was 19.23% on host body. Presence of dorso-lateral head margin with preocular slit; presence of maxillary palpi; absence of postpalpal process; moderately development of gular plate; evidence of long oblong terminal segment of antennae; presence of ocular comb; development of pronotal carina; presence of oval to oblong abdomen; presence of absolute tergites having only one tergal setae; genital characteristics were typical to the species; evidence of reduced basal apodeme; presence of large parameres and much fine in middle, forming wing shape structure; evidence of large and slender penis; development of weak genital sac.

3.6 Material examined

15 ♂, 10 ♀, lying on guinea fowl *Numida maleagris* (Linnaeus 1758), habitat include gular region, under wing feathers, breast, belly and leg, Province, Sindh, Pakistan, 2015–April to 2016–March.

3.7 *Goniocotes gallinae* (de Geer, 1776)

Type host: *Gallus gallus domesticus* Linnaeus, 1758

It is very small size and gray chewing lice. It was usually attached to feathers all time and belongs to family Philopteridae (Figure 5). During present investigation 45 specimens of *Goniocotes gallinae* (de Geer, 1776) were collected as highest prevalence 34.61% as compared to other species on host body. It was recorded first time as a new host and new locality record from the guinea fowl *Numida maleagris* (Linnaeus, 1758) Sindh, Pakistan. The head anterior margin usually circumfasciate, broadly rounded, convex anteriorly, evidence of deep and slit fine; presence of monomorphic antennae; absence of meso-metasternal plate and setae; absence of gular plate; presence of spindle and diamond shaped abdomen, with convex lateral margins; presence of small IX tergite, development of simple and complete tergal plate; genital characteristics were typical to species; evidence of short vulva, with membranous margins.

3.8 Material examined

45 ♀, lying on guinea fowl *Numida maleagris* (Linnaeus 1758), habitat include gular region, under wing feathers, breast, belly and leg. Province, Sindh, Pakistan, 2015–April to 2016– March.



Figure 4: *Menopon gallinae*.



Figure 5: *Goniocotes gallinae*.

An observation and examination of the data in the checklist of the world (Price *et al.*, 2003) reveals that other number of chewing lice *Colpocephalum tausi* Ansari, 195; *Cuclotogaster cinereus* Nitzsch, 1866; *Goniodes dissimilis* Denny, 1842 and *Lipeurus tropicalis* Peters, 1931; habitually infesting poultry fowls. It was investigated through research that the presence of parasitic insects on body of the host prevails because of increased temperature and humidity of particular regions is the favorable medium for increasing their fecundity rates (Sayeed *et al.*, 2005). It was also investigated that occurrence of chewing lice into two suborders of Mallophaga (Phthiratera: Insecta) were different. The suborder amblycera consisting of lice species were active and fast running and spend most of the time on the body surface of the fowls. In the suborder ischnocera consisting of lice species were less active and most of the time attached to feathers of fowls (Ash, 1960). It was concluded that 15 guinea fowls were examined and 13 were positive with total prevalence of 90.02% was occurred. Only 4 species were recovered as new host and new locality records

from the study area. This was the first investigation on local guinea fowl *Numida meleagris* (Linnaeus, 1758) from the different urban and rural localities of Province Sindh, Pakistan.

Conclusions and Recommendations

Presently two species of chewing lice *Menacanthus abdominalis* (Piaget, 1880) of family Menoponidae and *Goniocotes gallinae* (de Geer, 1776) of family Philopteridae were reporting first time from guinea fowl *Numida meleagris* (Linnaeus, 1758) from the study area and making a new host and new locality records in the world (Price *et al.*, 2003). Occurrence of chewing lice on host causes declining health and reduced production of eggs in hosts. Annoyance, frustration, impatience, aggravation, intolerance, and keenness were observed in fowls. Not sufficient work was carried out except Karachi from Sindh, Pakistan. The first work on lice was done before Indo-Pak, partition from Punjab (Faisalabad) from Pakistan. The study needs more research on different parameters to prevent host health like clinical pathology caused by fleas, mites and ticks on birds and to find out more results and we can prevent the poultry industry from great economic loss. Galliform birds (Phthiraptera: Insecta) carry large number of parasitic insects chewing lice which causes enormous pathogenicity in the host birds and decreased their health and food production

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Novelty Statement

Present research paper was recorded 04 chewing lice species *Menopon gallinae* (Linnaeus, 1758), *Menacanthus stramineus* (Nitzsh, 1818), *Menacanthus abdominalis* (Piaget, 1880) and *Goniocotes gallinae* (de Geer, 1776) from guinea fowl *Numida meleagris* (Linnaeus 1758), as new host and new locality records from study area Sindh, Pakistan.

Author's Contribution

Farheen Shaikh and Saima Naz conceived, designed and performed the experiments and wrote the paper.

Nadir Ali Birmani contributed examination and analysis tools.

Conflict of interest

The authors have declared no conflict of interest.

References

- Abeb, W., Asfaw, T., Genete, B., Kassa, B. and Dorchie, P., 1997. Comparative studies of external parasites and gastro-intestinal helminthes chickens kept under different management system in and around Addis Abeba (Ethiopia). *Rev. Med. Vet. Toulouse*, 148: 497-500.
- Ansari, M.A.R., 1944. Mallophaga found on Domestic fowl *Gallus gallus domesticus* Linnaeus, in the Punjab. *Indian J. Entomol.*, 5(1-2): 129-142.
- Arends, J.J., 1997. External parasites and poultry pests. In: (ed. B.W. Calnek], Disease of poultry, Iowa State University Press, Ames, Iowa.
- Ash, J.S., 1960. A study of Mallophaga of birds with particular reference to their ecology, *IBIS*, 102: 93-110. <https://doi.org/10.1111/j.1474-919X.1960.tb05095.x>
- Askew, R.R. 1971. Parasitic insects. Henieman, London.
- Audi, A.H. and Asmau, A.M., 2014. Prevalence of bird louse *Menacanthus cornutus* (Phthiraptera: Amblycera) in four selected poultry farms in Kano State, Nigeria, *Bajo PAS*, 7(1): 142-146. <https://doi.org/10.4314/bajopas.v7i1.26>
- Brown, N.S., 1974. The effect of louse infestation, wet feathers and relative humidity on the grooming behavior of the domestic chicken. *Poult. Sci.*, 53: 1717-1719. <https://doi.org/10.3382/ps.0531717>
- Clay, T., 1949. Piercing mouth parts in the biting lice (Mallophaga). *Nature*, 164: 617. <https://doi.org/10.1038/164617a0>
- Clayton, D.H., 1991. Co-evolution of avian grooming and ectoparasite avoidance. In Bird-parasite interaction: Ecology, evolution, and behavior, (eds. J.E. Loye and M. Zuk). Oxford University Press, Oxford, U.K.
- Cruickshank, R.H., Johnson, K.P., Smith, V.S., Adams, R.J., Clayton, D.H. and Page, R.D., 2001. Phylogenetic analysis of partial sequences of elongation factor I alpha identifies major groups of lice (Insecta: Phthiraptera), *Molecular*

- Phylogenetics and Evolution*, 19: 202-215. <https://doi.org/10.1006/mpev.2001.0928>
- Cummings, B.F., 1913. On some points in the anatomy of the mouth- parts of the Mallophaga, *Proc. Zool. Soc. Lon.*, 1913: 128-141. <https://doi.org/10.1111/j.1096-3642.1913.tb01989.x>
- Cummings, B.F., 1916. Studies on the Anoplura and Mallophaga, being a report on the collection from Mammals and Birds in the society's gardens Part II. *Proc. Zool. Soc. Lon.*, pp. 643-693. <https://doi.org/10.1111/j.1096-3642.1916.tb02041.x>
- De Vaney, J.A., 1976. Effects of the chicken body louse, *Menacanthus stramineus*, on caged layers. *Poult. Sci.*, 55: 430-435. <https://doi.org/10.3382/ps.0550430>
- Ilyes, M., Ahmed, B., Kheira, S., Hanene, D. and Fouzi, M., 2013. Prevalence and distribution of chewing Lice (Phthiraptera) in free range chickens from the traditional rearing system in the Algerian North East, Area of El-Tarf. *Int. J. Poult. Sci.*, 12(12): 721-725. <https://doi.org/10.3923/ijps.2013.721.725>
- Johnson, K.P. and Whiting, M.F., 2002. Multiple genes and the monophyly of Ichnocera (Insecta: Phthiraptera), *Mol. Phylog. Evol.*, 22: 101-110. <https://doi.org/10.1006/mpev.2001.1028>
- Kettle, P.R. and Pearce, D.M., 1974. Effect of the sheep body louse (*Damalinea ovis*) on host weight gain and fleece value, *N. Z. J. Exp. Agric.*, 2: 219-221. <https://doi.org/10.1080/03015521.1974.10427679>
- Kellogg, V.L., 1896. New Mallophaga, I, -with special reference to a collection made from maritime birds of the Bay of Monterey, California. *Proc. Calif. Acad. Sci.*, 6(2): 31-168.
- Lakshminarayana, K.V., 1979. A synoptic list of Mallophaga sens. lat. (Phthiraptera: Insecta) from India and adjacent countries together with host and regional indices. *Rec. Zool. Surv. India*, 75: 39-201.
- Lyal, C.H.C., 1985. Phylogeny and classification of Psocodea, with particular reference to lice (Psocodea: Phthiraptera). *Syst. Entomol.*, 10: 145-165. <https://doi.org/10.1111/j.1365-3113.1985.tb00525.x>
- Naz, S., Rizvi, S.A. and Sychra, O., 2010. The high rate of infestation of the chewing lice (Phthiraptera) in rock pigeons (*Columba livia*) in Pakistan. *Tropical Zoology Italy*, 23: 21-28.
- Nelson, B.C. and Murray, M.D., 1971. The distribution of Mallophaga on the domestic pigeon (*Columba livia*). *Int. J. Parasitol.*, 1: 21-29. [https://doi.org/10.1016/0020-7519\(71\)90042-7](https://doi.org/10.1016/0020-7519(71)90042-7)
- Nelson, B.C., 1972. A revision of the New World species of *Ricinus* (Mallophaga) occurring on Passeriformes (Aves). *University of California Publications in Entomology*, 68: 1-175.
- Nelson, W.A., Bell, J.F., Clifford, C.M. and Keirans, J.E., 1977. Interaction of ectoparasites and their hosts. *J. Med. Entomol.*, 13: 389-428. <https://doi.org/10.1093/jmedent/13.4-5.389>
- Palma, R.L., 1978. Side-mounting of lice: A detailed description of the Canada balsam technique. *The New Zealand Entomologist*, 6: 432-436. <https://doi.org/10.1080/00779962.1978.9722313>
- Price, R.D., Clayton, D.H., Hallenthal, R.A., Johnson, K.P. and Palma, R.L., 2003. The chewing lice: World checklist and biological overview. *Illinois Natural History Survey, Special Publication*, 24: 1-105+ X. <https://doi.org/10.5962/bhl.title.154191>
- Syed, K., Rizvi, S.A. and Naz, S., 2005. Seasonal effects on the population of chicken lice (Mallophaga: Insecta). *International Journal of Biology and Biotechnology*, 2(4): 921-924.
- Smith, V.S., 2001. Avian louse phylogeny (Phthiraptera: Ischnocera): A cladistic study based on morphology. *Zool. J. Linn. Soc.*, 132: 81-144. <https://doi.org/10.1111/j.1096-3642.2001.tb02272.x>
- Snodgrass, R.E., 1905. A revision of the mouth parts of the Corrodentia and the Mallophaga. *Trans. Am. Entomol. Soc.*, 31(4): 297-307.