Pak. J. Agri., Agril. Engg., Vet. Sci., 2022, 38 (2): 129-136
ISSN: 1023-1072 (Print), ISSN: 2663-7863 (Online)
https://doi.org/10.47432/2022.38.2.5

POPULATION DIVERSITY OF CHEWING LICE (PHTHIRAPTERA) INFESTING DUCKS AND GEESE (FAMILY ANATIDAE) IN SOUTHEAST PARTS OF PAKISTAN

S. Siyal*, S. Naz[1*], N. A. Birmani and A. K. Thebo

Department of Zoology, University of Sindh, Jamshoro, Pakistan

ABSTRACT

The birds and chewing lice relationship depends on environmental conditions that cause morbidity by feeding on feathers, irritating them, hence affecting their economic importance. In the present work, the statistical taxonomical analysis of the chewing lice was done using the population distribution, prevalence and host-parasite interaction. The chewing lice (Phthiraptera) were planned to study the population burden and infestation rate in ducks and geese in local water bodies in Sindh. The study was conducted between September 2018 and August 2021. Total of 124 birds, including *Anas acuta*, *A. crecca*, *A. platyrhynchos*, *A. querquedula*, *Aythya ferina*, *A. fuligula*, *A. nyroca*, *Anser albifrons*, *A. anser*, *Marmaronetta angustirostris* and *Spatula clypeata* were used. Amongst 124 host birds, only 58 birds were found infested with 46.77% prevalence of chewing lice. A total of 405 chewing lice were collected among them 137 males, 178 females and 90 nymphs were recovered, including 8 species, *Anaticola crassicornis* (Scopoli, 1763), *A. mergiserrati* (de Geer, 1778), *Anatoecous dentatus* (Scopoli, 1763), *A. icterodes* (Nitzsch, 1818), *Holomenopon fatemae* (Naz and Rizvi, 2012), *H. leucoxanthum* (Burmeister, 1838), *Trinoton anserinum* (Fabricius, 1805) and *T. qurequdulae* (Linnaeus, 1758). The highest abundance and frequency (%) of chewing lice recorded for *Anaticola crassicornis* were 125 and 30.86% respectively, whereas the lowest for *Anatoecus dentatus* were 12 and 2.96% respectively. Among birds, the highest host-wise prevalence of lice infestation was found in *A. ferina* (58.33%), whereas the least prevalence was in *A. albifrons* (22.22%). Among lice species, the highest mean intensity was recorded by *Anaticola crassicornis* (13.89±3.33) and the least mean intensity was for *Holomenopon fatemae* mean intensity (2.6±0.4). It was also the first collective report on the chewing lice population burden on anatid birds in the Sindh region of Pakistan.

Keywords: anatidae, chewing lice, intensity, prevalence, seasonal variations

INTRODUCTION

The chewing lice (Phthiraptera) feed mostly on dermal debris, feathers, hairs, and skin secretion of their host. The chewing lice are obligatory parasites of warm-blooded animals like birds and mammals; these are dependent on their hosts for the whole of their life cycle and are usually host-specific. They have numerous and diverse setae, short, stumpy but strong legs, which enable them to move freely among the complex structure of feathers. Apart from feathers, chewing lice can also feed on blood occasionally (Foster, 1969; Agarwal *et al.,* 1983; Saxena *et al.,* 1985; Clayton and Walther, 2001; Clayton *et al.,* 2004; Hinojosa-Sáez *et al.,* 2009; Chu *et al.,* 2019). Chewing lice are abundant ectoparasites of birds and mammals, they are adapted to live in the plumage or pelage of their hosts, and do not leave the host during their life cycle. The chewing lice normally show vertical transmission, during brooding and nursing of chicks (Clayton *et al.,* 2016). Chewing lice have a high capability to develop host specificity with their hosts; however, the species of chewing lice of anatid birds are found to be the least specific to their hosts among all avian lice around the world (Hinojosa-Sáez *et al.,* 2009; Escalante *et al.,* 2016).

There have been many studies conducted on the population distribution of the chewing lice on various birds of the order Anseriformes, conducted all over the world, focusing on the abundance, mean intensity of infestation and

*Corresponding author: syma.naz@usindh.edu.pk

prevalence of lice in birds, however, the seasonal variations in the population of lice have also been studied on these birds (Buscher, 1965; Canaris *et al.,* 1981; Thul, 1985; Hinojosa-Sáez *et al.,* 2009; Naz *et al.,* 2010; Grossi, 2013; Kumar *et al.,* 2013; Ahmad *et al.,* 2015; Bulgarella *et al.,* 2018; Galloway and Lamb, 2021). The variation in the temperature and humidity corresponds to the change in the population of lice and increases the rate and intensity of the infestation of these important commodities. The rate of infestation may also increase by geographical change, as is observed, the higher infestation of lice in rural areas and lower in urban areas (Mccrea *et al,* 2005; Sychra *et al.,* 2008; Audi and Asmau, 2014; Ahmad *et al.,* 2015; Di Blasi *et al.,* 2018).

The present study has been executed to estimate the population of chewing lice on various local and migrant ducks and geese in the region to find out the prevalence of lice affecting different aged ducks and geese from aquatic ecological zones, and to enumerate the burden of chewing lice infestation on host bodies (lice as a model), to find out the effects of high and low altitude humidity and temperature effect on the population of lice on ducks (ducks as a model) and the seasonal variations and their effects on the density of lice on ducks and geese (migration model) will be studied, as they start to migrate at the end of autumn, may lead to increase in the burden of lice on their bodies till the end of the winter season, when they start to go back to the northern parts. It is assumed to have a favourable environment for the chewing lice to enhance their population dynamics as the migratory birds reach the local water bodies and get in contact with other birds during the wintering, breeding and roosting in the region, hence can get infested with more number of lice. The data can give us the idea to check out how the bird's migration can affect the lice population on their host birds.

MATERIALS AND METHOD

This study was carried out from September 2018 to August 2021, and ducks were collected live from major lakes found in Sindh province situated in Naushehro Feroze, Larkana, Badin, Dadu, Kambar Shehdad Kot, Jamshoro and Thatta. A total of 124 birds of various ducks and geese were collected and examined for their lice. Birds were examined for chewing lice by visual examination, keeping the bird on a white plastic sheet, where they were checked and their lice were counted; birds were then released in the field. Some lice samples were collected and preserved in 80% ethanol for slide mounting and identification. In the field, the humidity and temperature were also noted down using a digital thermometer and hygrometer (HTC-2), China. Bird species were identified using Robert (1991), Grimmett *et al.* (1998) and Clements *et al.* (2021). Chewing lice were processed through the standard process of permanent slide mounting in Canada balsam.

The statistical taxonomical differences within the chewing lice species and their parasitological and ecological data were analyzed using the prevalence, burden of lice and intensity (mean±SE) were enumerated using MS Excel 2019; the data analysis and quantitative parameters including seasonal variations in the mean intensity, rate of infestation and prevalence of the lice infestation on their hosts were studied, following the methods of Bush *et al.* (1997), Rózsa *et al.*(2000) and Musa *et al.* (2012). The lice population in ducks and geese in the southern part of Pakistan was based on the three models including Parasite-Model, Host-Model and Migration-Model.

RESULTS AND DISCUSSION

During the present study, a total of 405 specimens of chewing lice comprising eight species, *Anaticola crassicornis* (Scopoli, 1763), *A. mergiserrati* (De Geer, 1778), *Anatoecus dentatus* (Scopoli, 1763), *A. icterodes* (Nitzsch, 1818), *Holomenopon fatemae* Naz and Rizvi, 2012, *H. leucoxanthum* (Burmeister, 1838), *Trinnoton anserinum* (Fabricius, 1805) and *T. qurequdulae* (Linnaeus, 1758) were recovered. These lice were collected from the feathers of 58 birds out of 124 different species of ducks and geese including the pintail (*Anas acuta* (Linnaeus), common teal (*A. crecca* (Linnaeus), mallard (*A. platyrhynchos* (Linnaeus), garganey (*A. querquedula* (Linnaeus), common pochard (*Aythya ferina* (Linnaeus), tufted duck (*A. fuligula* (Linnaeus), ferruginous duck (*A. nyroca* (Guldenstadt), graylag goose (*Anser anser* (Linnaeus), greater white-fronted goose (*A. albifrons* (Linnaeus), marbled duck (*Marmaronetta angustirostris* (Reichenbach) and common shoveler duck (*Spatula clypeata* (Linnaeus) (Plate A: Figure 1), with the overall prevalence of 46.77% and total burden of lice on all birds collectively was recorded 6.982 (Table 1). The data were collected from various lakes and ponds of Sindh province located all over the Sindh region from fall 2018 to fall 2021. Among the birds, *Aythya ferina* was the most

prevalent for the infestation which was recorded at 58.33%, followed by *Anas acuta* (57.14%), *A. platyrhynchos* (54.54%) and *A. crecca* (54.16%), these findings are supported by previous ecological studies carried out on various types of ducks and their chewing lice species (Hinojosa-Sáez *et al.,* 2009; Kumar *et al.,* 2013; Ahmad *et al.,* 2015). The burden or mean abundance was also checked to analyze the effects of the chewing lice population on each host species (Table 1, Figure 2).

Among the lice, the most common species of chewing lice are in high abundance and found most frequent in birds; like other studies (Schlatter *et al.,* 1983; Thul, 1985; Forrester *et al.,* 1994; Hinojosa-Sáez *et al.,* 2009; Naz *et al.,* 2010; 2016; Kumar *et al.,* 2013; Ahmad *et al.,* 2015), the present studies also showed that the most frequent species was *Anaticola crassicornis* with the frequency of 30.86% and the highest abundance and mean intensity were found at 125 and 13.89±3.33 respectively that also observed in Forrester *et al.* (1994), Ahmad *et al.* (2015), Bulgarella *et al.* (2018) and Begum *et al.* (2019), however the least frequency 3.2% was found by *Holomenopon fatemae* and lowest abundance and mean intensity was also recorded for both species of the genus *Holomenopon* i.e. 12-13 and 2.6±0.4 respectively, followed by *Trinoton anserinum* i.e. 3.33±0.614 (Table 2; Figure 3).

The gender-wise population was also checked to determine the reproductive capability of these lice species, as the female population is always observed higher than males and the nymphal population is higher than adults (Hamstra and Badyaev, 2009; Naz *et al.,* 2010; Kumar *et al.,* 2013; Ahmad *et al.,* 2015; Begum *et al.,* 2019; Siyal *et al.,* 2019; Galloway and Lamb, 2021); in the present study, 137 males, 178 females and 90 nymphs were collected; the sex ratio showed the similar results, but age ratio showed the abundance of nymphs is lower than adults (Table 2). This factor may be affected by the weathering conditions, as the climate of Sindh province is normally getting more dry, warm and windy, especially near the water bodies. The water in the lakes and rivers of Sindh become dry or has less water during most of the summer season spanning about 7 months of the year and the temperature reaches up to 45-50℃ (Khan and Gadiwala, 2013; Abbas *et al.,* 2018; Umar *et al.,* 2018). Hence, it is possible that due to the sandy airy parts near the rivers and lakes like River Indus, the fine particles of dust and sand can penetrate the feathers and help the birds to eliminate the lice, especially the young nymphs that have a weak grip on feathers of their hosts (Clayton *et al.,* 2010; Grossi, 2013; Bush and Clayton, 2018; Galloway and Lamb, 2021).

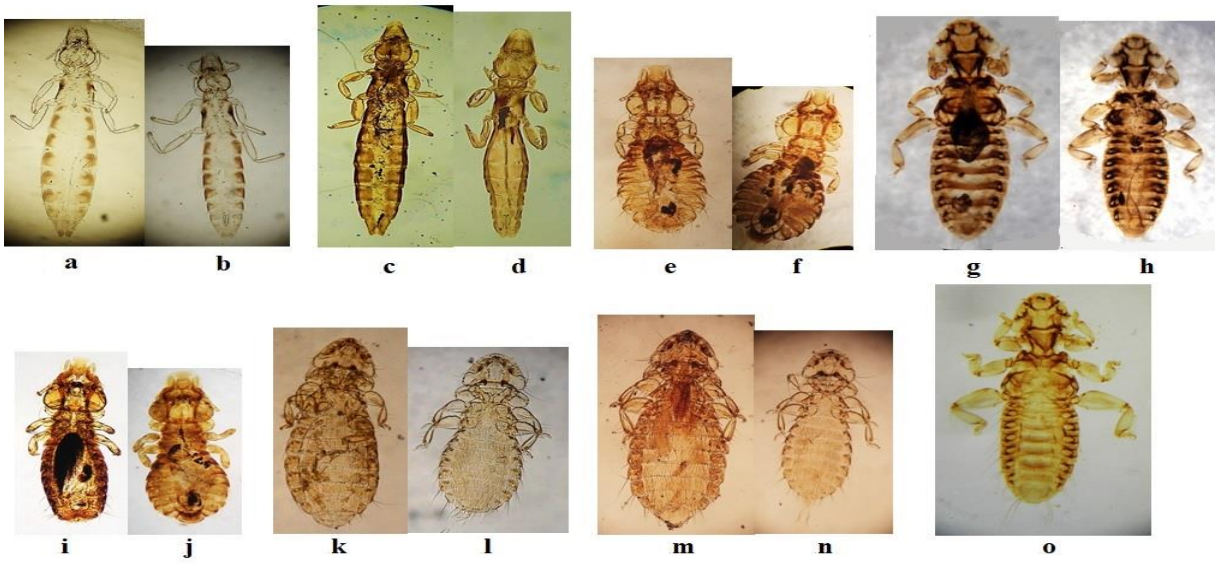


Figure 1. The microphotographs of chewing lice species recovered from various species of ducks and geese during present study: *Anaticola crassicornis* (Scopoli, 1763)-a: female, b: male; *Anaticola mergiserrati* (de Geer, 1778)-c: female, d: male; *Anatoecous dentatus* (Scopoli, 1763)-e: female, f: male; *Trinoton qurequdulae* (Linnaeus, 1758)-g: female, h: male; *Anatoecus icterodes* (Nitzsch, 1818)-i: female, j: male; *Holomenopon fatemae* Naz and Rizvi, 2012-k: female, l: male; *Holomenopon leucoxanthum* (Burmeister, 1838)-m: female, n: male; *Trinoton anserinum* (Fabricius, 1805)-o: female.

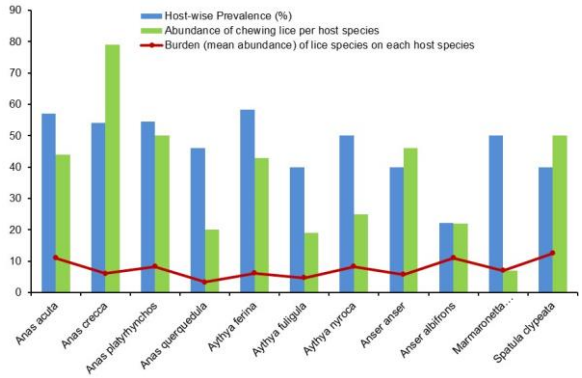


Figure 2. Comparison of the prevalence and abundance of infestation that exerts burden on the birds examined during the present study (Host Model)

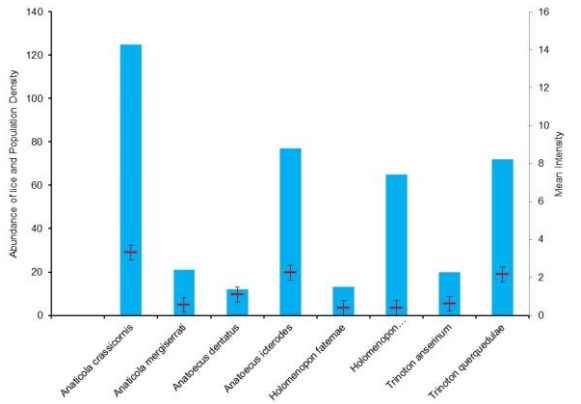


Figure 3. Comparison of the mean intensity and total abundance of chewing lice on all infested birds with variation in the population density during the present study (Lice Model)

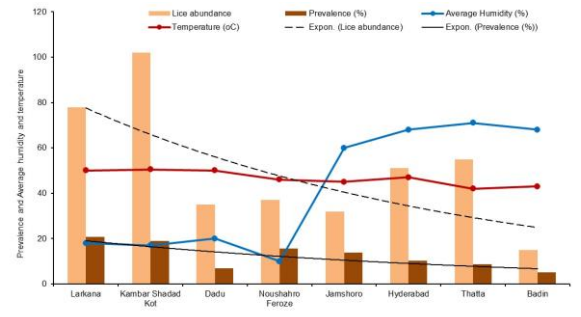


Figure 4. Correlation between the lice abundance with the average humidity and temperatures in various districts of Sindh province (south-east part of the country) during the present study (Migration Model). The exponential curves are declined as the locality altitude become lower with reference to sea level

The effects of average humidity and temperature of the study sites were also observed (Table 3) that where the humidity was low with the rise of temperature, the abundance of the lice population was recorded relatively higher (Figures 3a and 3b). The temperature, humidity and high altitude of the study site also cause a positive correlation with the lice population in birds (Figure 4), the lice abundance and prevalence in the birds were observed relatively higher in warmer and dry areas than that in lower altitude with more humid areas. These findings are also supported by previous studies (Hamstra and Badyaev, 2009; Grossi, 2013; Ahmad *et al.,* 2015; Gustafsson *et al.,* 2019; Galloway and Lamb, 2021). The seasonal variation in the population distribution of chewing lice in the different duck species was also checked. The study was undertaken for three years data hence the major seasons, winter and summer were targeted to observe the lice population distribution among ducks (Table 4). The three-years-winter and three-years-summer data showed the independent distribution of lice; among the species which were recorded higher in abundance in summer were *Anaticola crassicornis* and *Trinoton querquedulae* while other species were mostly relatively higher in winter Figure 5. The overall infestation of chewing lice was recorded higher in winter than in summer; the individual lice species abundance was also compared in both seasons showing mostly higher population in the colder and dry season Figure 6 a-c (Hamstra and Badyaev, 2009; Kumar *et al.,* 2013; Ahmad *et al.,* 2015; Naz *et al.,* 2016; Galloway and Lamb, 2021).

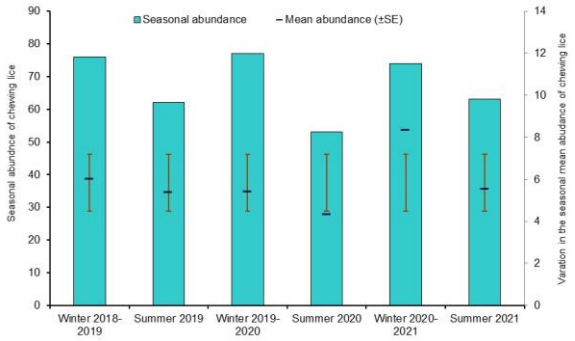
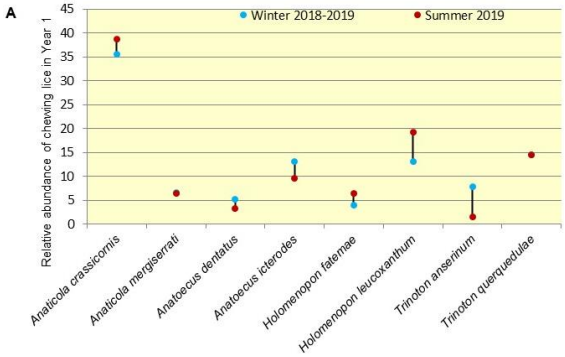


Figure 5. Comparison of the seasonal abundance and the variation in the means of abundance of the chewing lice infestation in ducks during the winter and summer seasons of the three years from August 2018 to September 2021.



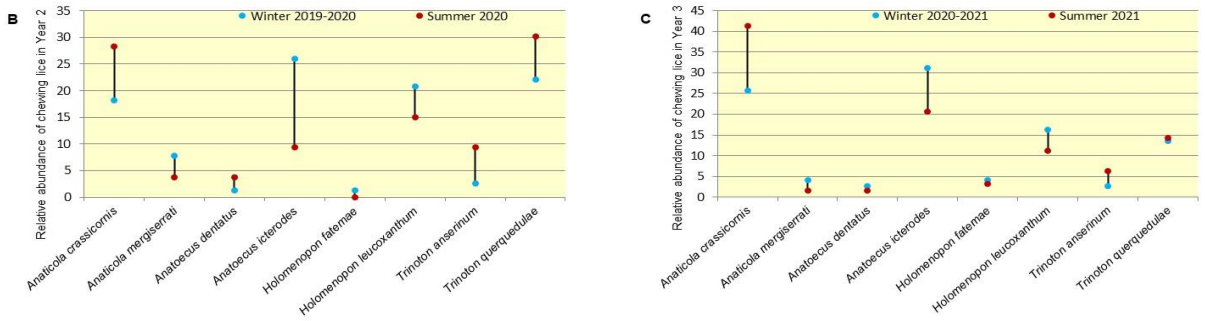


Figure 6. Comparison of relative abundance of chewing lice during the winter and summer seasons of the three years of present study, A: Year One-2018 and 2019; B: Year Two-2019 and 2020; C: Year Three-2020 and 2021.

Table 1. Ducks and geese species with their prevalence and rate of infestation from some south-east parts of Pakistan

Birds species	Sample size of hosts	Infested hosts	Host-wise Prevalence (%)	Abundance of chewing lice per host species	Burden (mean abundance) of lice species on each host species
Anas acuta	7	4	57.14	44	11
Anas crecca	24	13	54.16	79	6.076
Anas platyrhynchos	11	6	54.54	50	8.333
Anas querquedula	13	6	46.15	20	3.333
Aythya ferina	12	7	58.33	43	6.142
Aythya fuligula	10	4	40	19	4.75
Aythya nyroca	6	3	50	25	8.333
Anser anser	20	8	40	46	5.75
Anser albifrons	9	2	22.22	22	11
Marmaronetta angustirostris	2	1	50	7	7
Spatula clypeata	10	4	40	50	12.5
Total	124	58	46.77	405	6.982

Table 2. Quantitative parasitological parameters to analyze the population distribution of chewing lice on ducks and geese in the present study

Chewing lice species	Abundance of lice	Number of hosts being infested with each louse species	Lice population density	Frequency (%)	Mean Intensity (mean±SE)	Sex ratio (M:F)	Age ratio (N:A)	Range
Anaticola crassicornis	125	37	13.88	30.86	13.89±3.33	1:1.23	1:3.62	1-10
Anaticola mergiserrati	21	13	3.5	5.18	3.5±0.56	1:1.42	1:4.25	1-3
Anatoecus dentatus	12	10	3.0	2.96	3.0±1.08	1:1.5	1:5	1-2
Anatoecus icterodes	77	31	8.55	19.01	8.55±2.25	1:1.1	1:4.5	1-5
Holomenopon fatemae	13	10	2.6	3.20	2.6±0.4	1:1.5	1:3.33	1-2
Holomenopon leucoxanthum	65	26	9.28	16.04	2.6±0.4	1:1.14	1:2.62	1-5
Trinoton anserinum	20	14	3.33	4.93	3.33±0.614	-	1:4	1-2
Trinoton querquedulae	72	29	9.0	17.77	9.0±2.15	1:1.07	1:3	1-4

Table 3. Bird species examined in different districts with average humidity and temperature effects on their prevalence of lice infestation during present study

Districts	Location	coordinates	Average Humidity (%)	Temperature (ºC)	Birds sample size	Infested Birds	Lice abundance	Prevalence (%)
Larkana	Near Dargah Mohban	27°14'24.2"N 68°09'50.4"E	18	50	22	12	78	20.68
Kambar Shadad Kot	Hamal Lake	27°19'44.8"N 67°38'23.8"E	17	50.5	20	11	102	18.96
	Drigh Lake	27°33'31.8"N 67°55'37.7"E						
Dadu	Manchar Lake-northern side	26°26'35.6"N 67°43'25.4"E	20	50	10	4	35	6.89
	Manchar Lake-north west side	26°27'33.4"N 67°33'19.5"E						

Noushahro Feroze	Near Bhorti	26°57'19.3"N 68°00'56.2"E	10	46	28	9	37	15.51
Jamshoro	Manchar Lake-southern side	26°21'25.9"N 67°43'04.1"E	60	45	19	8	32	13.79
	Talti Lake	26°30'14.2"N 67°47'51.4"E						
Hyderabad	Citizen Colony	25°24'23.0"N 68°20'57.8"E	68	47	11	6	51	10.34
	Site Area	25°21'08.8"N 68°23'55.3"E						
Thatta	Keenjhar Lake	24°51'39.3"N 68°01'00.2"E	71	42	9	5	55	8.62
	Hadero Lake	24°49'39.2"N 67°51'45.5"E						
Badin	Tando Bago	24°50'39.0"N 68°58'43.2"E	68	43	5	3	15	5.17

Table 4. Seasonal variation in the relative abundance of all chewing lice species recorded during the present study in the southern part of the country.

Chewing lice species seasons	***Anaticola crassicornis***	***Anaticola mergiserrati***	***Anatoecus dentatus***	***Anatoecus icterodes***	***Holomenopon fatemae***	***Holomenopon leucoxanthum***	***Trinoton anserinum***	***Trinoton querquedulae***	**Mean abundance**
Winter 2018-2019	35.526	6.578	5.263	13.157	3.947	13.157	7.894	14.473	12.66±2.45
Summer 2019	38.709	6.451	3.225	9.677	6.451	19.354	1.612	14.516	10.33±2.20
Winter 2019-2020	18.182	7.792	1.298	25.974	1.298	20.782	2.597	22.077	12.83±2.21
Summer 2020	28.302	3.773	3.773	9.434	0	15.094	9.434	30.188	8.83±1.77
Winter 2020-2021	25.675	4.054	2.702	31.081	4.054	16.216	2.702	13.513	12.33±3.41
Summer 2021	41.269	1.587	1.587	20.634	3.174	11.111	6.352	14.285	10.5±2.26

CONCLUSION

The present study findings reveal that the chewing lice infestation in ducks and geese was recorded as more prevalent in winter in the three years with some slight lower in the summer season Figures 5 and 6. It was observed that the ducks of genus *Anas* and *Aythya* were more susceptible to the lice infestation; however, the high frequency and intensity among the lice were recorded for the ischnoceran lice (*Anaticola crassicornis, A. mergiserrati, Anatoecus dentatus* and *A. icterodes*) as compared to the amblyceran lice (*Holomenopon fatemae, H. leucoxanthum, Trinoton anserinum* and *T. querquedulae*). This is the first comprehensive epidemiological data on chewing lice on various species of ducks and geese in Sindh. It is also undertaken for the first time with the concept of the lice (parasite) and ducks (host) model, which can be studied further to understand the host-parasite interaction with the seasonal variations in the lice population in migratory birds.

ACKNOWLEDGEMENTS

The authors acknowledge the Higher Education Commission, Islamabad for the funding under NRPU Research Project No. 20-4514; also acknowledge the Sindh wildlife department for allowing the scholars to collect the birds in the field.

CONFLICT OF INTEREST

There is no conflict of interest between the authors before, during or after the publication of this work.

AUTHOR'S CONTRIBUTION

S. Siyal: Generated the main idea of the work, written the first draft, illustrations were made

S. Naz: Finalized the manuscript, analyzed the data, determined the specimens

N. A. Birmani: Helped in collection and laboratory work

A. K. Thebo: Helped in collection, experimental work and microscopy of the specimens

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(Received: June 30, 2022; Accepted: October 14, 2022)