Chewing lice (Phthiraptera: Amblycera, Ischnocera) on birds in the Kızılırmak delta, Turkey

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SUMMARY

The goal of this research was to detect lice species on birds sampled in Cernek Bird Ringing Station located in Kızılırmak delta in Turkey between May 2014 and October 2015. Birds were examined for lice infestation. A total of 619 bird species were examined, and lice were detected on 117 of the 619 birds (18.90%). A total of 21 genera and 35 species of chewing lice were detected on the infested birds. Six of these were Amblyceran genera; the other 15 were Ischnoceran genera. Five lice species were in the genera *Menacanthus* and *Brueelia*; four lice species belonged to the genus *Philopterus,* three to the genus *Ricinus,* and two to the genus *Actornitophilus*. In this study, several species were recorded for the first time in Turkey. These species included *Lipeurus caponis* from *Phasianus colchicus*, *Ardeicola celeris* from *Ixobrychus minutus*, *Rallicola ortygometrae* from *Crex crex*, *Actornitophilus spinulosus* and *Lunaceps* sp. from *Limosa limosa*, *Menacanthus fertilis* from *Upupa epops*, *Penenirmus serrilimbus* from *Jynx torquilla*, *Menacanthus curuccae* from *Luscinia luscinia*, *Iduna pallida*, *Sylvia atricapilla* and *Sylvia communis, Myrsidea sp.* from *Riparia riparia* and *Brueelia* sp. from *Phylloscopus trochilus* and *Ficedula albicollis*, *Philopterus desertus* and *Penenirmus* sp. from *Muscicapa striata*, *Philopterus rapax* from *Fringilla montifringilla*, *Ricinus dolicocephalus* from *Oriolus oriolus*, *Philopterus reguli* and *Ricinus frenatus* from *Regulus regulus*, *Ricinus elongatus* from *Turdus iliacus* and *Turdus merula*, and *Brueelia marginata* from *Turdus philomelos* Additionally, *A. celeris* from *I. minutus, M. curuccae* from *I. pallida,* and *Brueelia* sp. from *Phylloscopus trochilus* and *Ficedula albicollis* were reported for the first time on these bird species.

Keywords: Amblycera, Ischnocera, Chewing Lice, Passeriformes, Birds

RÉSUMÉ

Identification des poux (Phthiraptera: Amblycera, Ischnocera) présents sur les oiseaux dans le delta Kızılırmak, Turquie

L'objectif de cette étude était la détection des espèces de poux chez les oiseaux prélevés à la station ornithologique de Cernek située dans le delta de Kızılırmak en Turquie entre mai 2014 et octobre 2015. Un total de 619 oiseaux ont été examinés, des poux ont été détectés sur 117 d'entre-eux (18,9%). Au total, 21 genres et 35 espèces de poux broyeurs ont été détectés. Six d'entre eux appartenaient au genre Amblyceran, 15 au genre Ischnoceran. Cinq espèces de poux étaient dans les genres Menacanthus et Brueelia; Quatre appartenaient au genre Philopterus, trois au genre Ricinus, et deux au genre Actornitophilus. Parmi les espèces identifiées plusieurs ont été retrouvées pour la première fois en Turquie. Ces espèces incluaient Lipeurus caponis isolé de Phasianus colchicus, Ardeicola celeris d'Ixobrychus minutus, Rallicola ortygometrae de Crex crex, Actornitophilus spinulosus et Lunaceps sp. de Limosa limosa, Menacanthus fertilis d'Upupa epops, Penenirmus serrilimbus de Jynx torquilla, Menacanthus curuccae de Luscinia luscinia, Iduna pallida, Sylvia atricapilla et S. communis, Myrsidea sp. De Riparia riparia et Brueelia sp. de Phylloscopus trochilus et Ficedula albicollis, Philopterus desertus et Penenirmus sp. de Muscicapa striata, Philopterus rapax de Fringilla montifringilla, Ricinus dolicocephalus d'Oriolus oriolus, Philopterus reguli et Ricinus frenatus de Regulus regulus, Ricinus elongatus de Turdus iliacus et T. merula et Brueelia marginata de Turdus philomelos En outre, A. celeris de I. minutus, M. curuccae de I. pallida et Brueelia sp. de Phylloscopus trochilus et Ficedula albicollis ont été signalés pour la première fois sur ces espèces d'oiseaux.

Mots-clés: Amblycera, Ischnocera, Poux, Passeriformes, Oiseaux

Introduction

Approximately 10,500 bird species are currently recognized worldwide [37]. Out of these, 482 species occur in Turkey [56]. There are more than 250 genera and more than 6,000 species in Phthiraptera. Approximately 4,500 of these species delimitations have been considered to be valid. Most of these species (approximately 4,000) have been recorded on birds [49].

There are 150 louse species that infest birds in Turkey, as has been documented in recent studies [1,4-6, 17-29, 38, 39, 40, 41, 47]. Several chewing lice species have been identified on Turkish bird species, such as *Cuclotogaster heterographus* (Nitzsch [in Giebel], 1866 on Pheasants (Phasianus colchicus) [20], Mulcticola hypoleucus (Denny, 1842) on Nightjars (*Caprimulgus europaeus*) [18] and *Brueelia nebulosa* (Burmeister, 1838), *Menacanthus eurysternus* (Burmeister, 1838), *Myrsidea cucullaris* (Nitzsch, 1818) and *Sturnidoecus sturni* (Schrank, 1776) on Starlings (*Sturnus vulgaris*) [21]. Aksin [6] reported *Cuclotogaster cinereus* (Nitzsch, 1866), *Goniodes astrocephalus* (Burmeister, 1838) and *Menacanthus abdominalis* (Piaget, 1880) on Common Quails (*Coturnix coturnix*) for the first time in Turkey. In a study performed on Lake Kuyucuk in Kars [22], Charadriiform birds were examined, and 88% of them were infested with lice. In this study, 20 lice species were reported for the first time from Turkey [22]. In another study conducted at Lake Kuyucuk, 51 passerine birds belonging to 22 species were examined, and 21.57% of these species were infested. Five lice species were recorded for the first time in Turkey: *Menacanthus pusillus* (Niztsch, 1866) on *Anthus spinoletta, Melanocorypha calandra* and *Motacilla flava*; *Menacanthus chrysophaeus* (Kellogg, 1896) on *Emberiza schoeniclus*; *Myrsidea rustica* (Giebel,

1874) on *Hirundo rustica*; *Brueelia cruciata* (Burmeister, 1838) on *Lanius collurio* and *Penenirmus rarus* (Zlotorzycka, 1976) on *Phylloscopus collybita*. Lice surveys were conducted on 31 bird species belonging to nine orders, and 18 lice species were detected. Thirteen of these species were the following: *Actornithophilus piceus piceus* (Denny, 1842), *Anaticola phoenicopteri* (Coincide, 1859), *Anatoecus pygaspis* (Nitzsch, 1866), *Colpocephalum heterosoma* Piaget, 1880, *C. polonum* Eichler and Zlotorzycka, 1971, *Fulicoffula lurida* (Nitzsch, 1818), *Incidifrons fulicia* (Linnaeus, 1758), *Meromenopon meropis* Clay ve Meinertzhagen, 1941, *Meropoecus meropis* (Denny, 1842), *Pseudomenopon pilosum* (Scopoli, 1763), *Rallicola fulicia* (Denny, 1842), *Saemundssonia lari* Fabricius, O, 1780), and *Trinoton femoratum* Piaget, 1889 have been recorded from Turkey for the first time in Central Anatolia [24]. In a study performed on lice species on 23 bird species belonging to the orders Anseriformes, Charadriiformes, Coraciiformes, Falconiformes, Gruiformes and Passeriformes, seven lice species were detected. These lice species were the following: *Actornithophilus multisetosus* (Blagoveshtchensky, 1940), *Cummingsiella ambigua* (Burmeister, 1838), *Menacanthus alaudae* (Schrank, 1776), *Menacanthus curuccae* (Schrank, 1776), *Menacanthus eurysternus* (Burmeister, 1838), *Myrsidea picae* (Linnaeus, 1758), *Pseudomenopon scopulacorne* (Denny, 1842) [23]. Dik and Dinçer [26] reported the following two species for the first time in Turkey: *Ricinus elongatus* (Olfers, 1816) and *Brueelia merulensis* (Denny, 1842), which infested blackbirds (*Turdus merula*). In those studies of lice on the birds of the Kızılırmak delta, several new louse species were added to the Turkish fauna [1, 29]. The goal of this study was to detect lice species on the birds of the Kızılırmak delta in Turkey.

Materials and Methods

This research was performed at the Cernek Bird Ringing Station (41^{0}38'35"N, 36^{0}05'02"E) in the Kızılırmak delta, Samsun in Turkey (Figure I), between March 2014 and October 2015. More specifically, the study was conducted during the spring and autumn bird migration seasons (i.e., from March to May and then from August to October). Most of the examined birds were captured at the Cernek Ringing Station with mist-nets of 16-mm mesh size. The mist-nets were positioned in a scrub area between Cernek Lake and the Black Sea and were controlled from sunrise to sunset every day during the migration season. The ringing study and the study site are described by Barış et al. [10]. Birds were identified according to Baker, 1993 [8] and Svensson, 1992 [53] as well as according to the personal experience of the ringers. Birds were examined for the presence of lice.

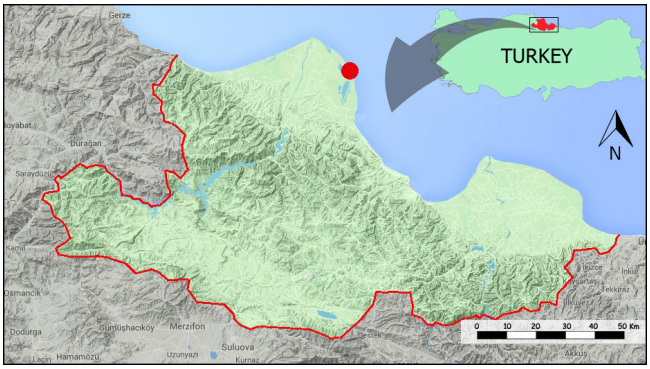

FIGURE 1: Location of the study site (Kızılırmak delta) in Turkey (red dot-Cernek Ringing Station)

Once captured, birds were taken from the mist-nets and moved to the bird ringing centre in holding bags. Each ringed bird was first examined visually for louse infestation; some of the birds were sprayed with synthetic pyrethroid insecticides [Avispray* (Tetramethrin + Piperonil butoxide), Biyoteknik, İstanbul, Turkey]. Following insecticide treatment, birds were placed in individual paper bags for 20 – 30 minutes and were then released. Materials accrued in the paper bags were poured into petri dish and examined by naked eye and with the aid of a lens. Detected lice were taken with pliers and placed into small glass bottles containing 70% alcohol and were labeled with the names of birds, numbers of rings, date and location. Louse samples were cleared in 10% KOH for 24 hours, rinsed in distilled water and were then kept in 70% and 99% alcohol serials for 24 hours. The transparent specimens were mounted in Canada balsam separately as permanent slides. The slides were dried in an incubator at 50-60 ^{0}C for 15-30 days, examined on a Leica DM 750 binocular phase-contrast microscope and were identified at the genus and/or species level using appropriate references [7, 9, 12-15, 31, 32, 34, 43, 44, 46, 49, 51, 54, 55, 57, 59, 60].

Chi-square tests were used for data of countable traits. T-tests (used for between ratios) were used for traits that were found to bear important differences between groups.

Results

During the study period, 619 birds were captured. These birds represented 73 bird species belonging to 33 different families of 13 orders. Lice were detected on 117 out of the 619 birds (18.90%). Lice were detected on 25 different bird species out of the 73 that were examined. A total of 21 genera and 35 species of lice were detected on infested birds. Six genera of lice belonged to the suborder Amblycera: *Actornitophilus, Colpocephalum, Menacanthus, Meromenopon, Myrsidea, Ricinus*. Fifteen of the following genera belonged to the suborder Ischnocera: *Alcedofulla, Ardeicola, Brueelia, Degeeriella, Goniodes, Lipeurus, Lunaceps, Maculinirmus, Meropoecus, Meropsiella, Mulcticola, Penenirmus, Philopterus, Quadraceps* and *Rallicola* (Table I).

The most prevalent genera were *Menacanthus* and *Brueelia*. In the genus *Menacanthus*, five species—*Menacanthus agilis, M. camelinus M. curuccae* (Figures II.A and II.B), *M. eurysternus* and *M. fertilis*—were identified. In the genus *Ricinus*, three species—*Ricinus frenatus, R. dolicocephalus* and *R. elongatus* (Figures III.A and III.B)—were identified. In the genus *Actornitophilus*, two species—*Actornitophilus totani* and *A. spinulosus* (Figures II.C and III.C)—were identified. Only one species *Colpocephalum turbinatum* (Figure II.D) was identified in the genus *Colpocephalum*. One species was identified in *Myrsidea*—*Myrsidea rustica*—and in *Meromenopon*—*Meromenopon meropis*. *Menacanthus* samples were collected from the Yellow Wagtail (*M. flava*) and the European Robin (*E. rubecula*). A *Myrsidea* specimen was collected from the Sand Martin (*R. riparia*). These samples were not included in the previous list because they could not be identified at the species level because the specimens were in the nymphal stage (Table I).

In Ischnocera, five lice species were in the genus *Brueelia*: *Brueelia cruciata* (Figure V.A), *B. domestica, B. jacobi, B. marginata* and *B. merulensis*. Four lice species were identified in the genus *Philopterus*: *Philopterus desertus, P. fringillae, P. rapax*, *P. reguli* (Figures IV.A, IV.B and IV.C). One lice species was identified in each of the following genera *Alcedoffula* (*A. alcedinis*), *Ardeicola* (*A. celeris* (Figure V.D)), *Degeeriella* (*D. nisus*), *Goniodes (G. astrocephalus), Lipeurus* (*L. caponis* (Figure V.C), *Lunaceps* (*Lunaceps* sp.) *Maculinirmus* (*M. mundus*), *Meropoecus* (*M. meropis*), *Meropsiella* (*M. apiastri*), *Mulcticola* (*M. hypoleucus*), *Penenirmus* (*P. serrilimbus* (Figure IV.D)), *Quadraceps* (*Q. obscurus*) and *Rallicola* (*R. ortygometrae* (Figure V.B)). The *Brueelia* samples (1♀) (possibly a new species) collected from *Ficedula albicollis* and *Phylloscopus trochilus* (1 nymph) were not identified to the species level. The *Penenirmus* samples were destroyed when they were collected from *Muscicapa striata* and *Sylvia melanocephala*; therefore, these samples were not identified to species (Table I).

The infestation rate in birds of the orders Gruiformes, Pelecaniformes and Charadriiformes was 100%; however, only one bird was sampled in each order. The infestation rates for Piciformes and Passeriformes were the lowest at 43% and 13%, respectively, while no lice were detected on samples from the orders Falconiformes, Cuculiformes and Strigiformes. At the family level, infestation rates were 100% in Ardeidae, Meropidae, Oriolidae, Rallidae and Scolopacidae; 75% in Accipitridae; 80% in Hirundinidae; 67% in Phasianidae; and 67% in Upupidae. Infestation rates were lowest in the following families: Sylviidae (13%), Acrocephalidae (10%), Passeridae (5%) and Muscicapidae (5%). No lice species were detected in Aegithalidae, Cettidae, Emberizidae, Locustellidae, Paridae, Prunellidae and Sturnidae.

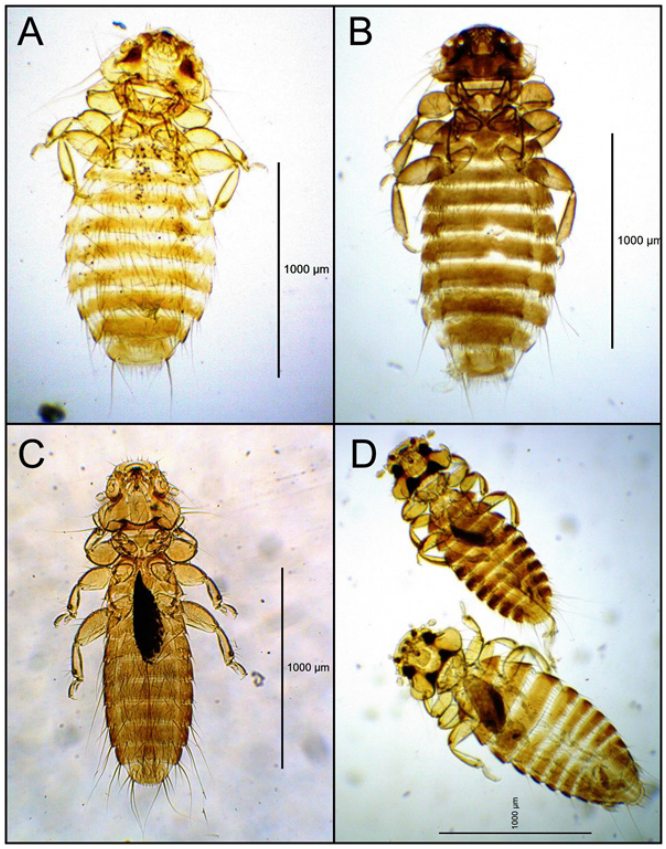

Figure 2: Original pictures of Amblyceran louse species. A: *Menacanthus camelinus*, female (from *L. collurio*); B: *Menacanthus curuccae*, female (from *S. communis*); C: *Actornitophilus totani*, male (from *T. glareola*); D: *Colpocephalum turbinatum,* male (top) and female (bottom) (from *C.aeruginosus*).

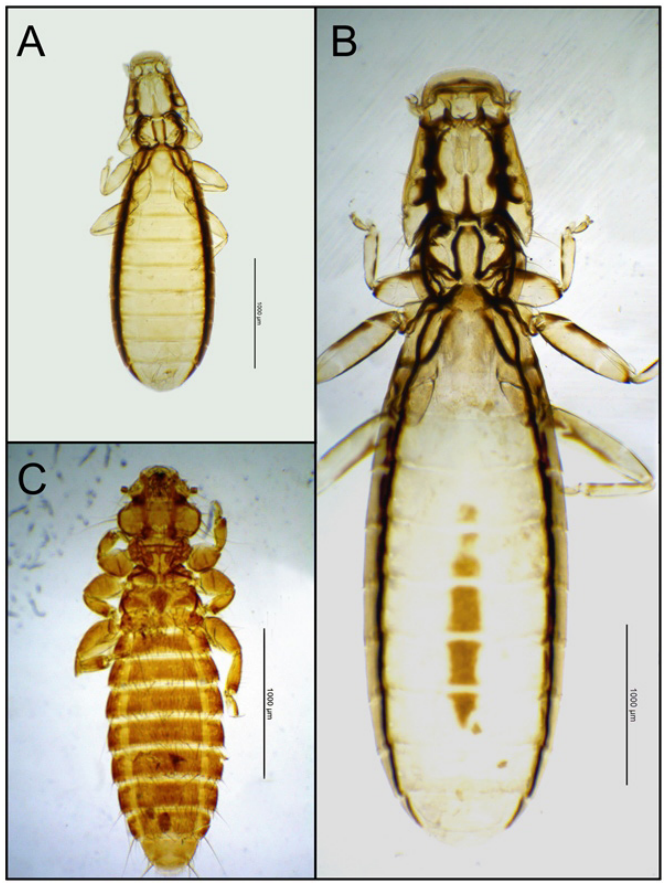

Figure 3: Original pictures of Amblyceran louse species. A: *Ricinus frenatus*, female (from *R. regulus*); B: *Ricinus dolicocephalus*, female (from *O. oriolus*); C: *Actornitophilus spinulosus*, female (from *L. limosa*).

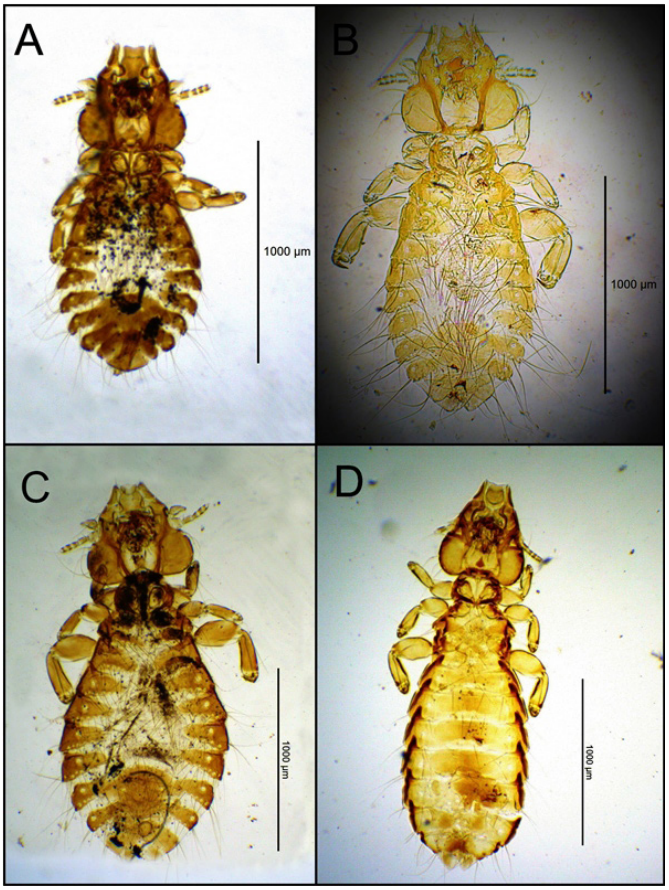

Figure 4: Original pictures of Ischnoceran louse species. A: *Philopterus desertus*, male (from *M. striata*); B: *Philopterus rapax*, female (from *F. montifringilla*); C: *Philopterus reguli*, female (from *R. regulus*); D: *Penenirmus serrilimbus*, female (from *J. torquilla*).

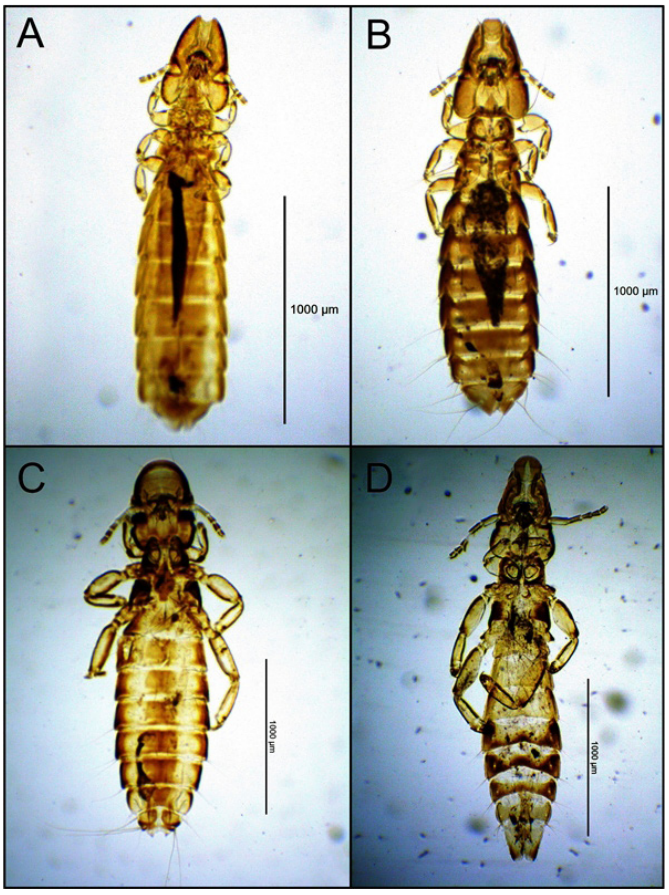

Figure 5: Original pictures of Ischnoceran louse species. A: *Brueelia cruciata*, female; B: *Rallicola ortygometrae*, female; C: *Lipeurus caponis*, female; D: *Ardeicola celeris*, male.

Because there were not enough data to statistically analyse infestation rate at the order level, a Chi-square test was only used at the family level. Oriolidae and Meropidae both had infestation rates that were higher compared to other families ($p= 0.019$).

The rate of infestation was higher in Hirundinidae than in other families, except for Oriolidae and Meropidae ($p <0.05$). The rates of infestation in Laniidae, Turdidae and Picidae were similar to one another. The rate of infestation in Alcedidae was higher than the rate of infestation in Muscicapidae, Passeridae, Acrocephalidae and Sylviidae ($p<0.05$). The rates of infestation in birds of Phylloscopidae, Sylviidae, Acrocephalidae, Passeridae and Muscicapidae were lower. Bird families with less than five birds were excluded from the analysis.

During the sampling period, infestation rates were higher in October (24%) and April (22.92%) than in August (17.50%) and March (17.39%). Lice infestation rates then dropped in May (15.87%) and September (12.30%). The density of captured birds was the highest in August (200 birds) and September (187 birds); the density of birds was the lowest in March (23 birds) and October (50 birds). Infestation rates were the highest in October; infestation rates were the lowest in September. The difference between infestation rates was statistically significant only in September ($p=0$) and in October ($p=0.0289$) relative to other months.

Discussion

Increasing numbers of surveys for lice species on birds in Turkey are being conducted. To date, more than half of the bird species present in Turkey have been examined, and more than 150 lice species have been identified on these bird species. Despite all of this research, lice were not detected on some of the examined bird species. Açıcı et al. [1] performed the first study on lice on birds from the Kızılırmak delta. They examined 189 birds belonging to 37 species. Thirty-two (17%) of the birds of 11 different species were infested with lice. A total of 88 lice specimens were collected, and 13 lice species were identified. Chewing lice have been reported from the birds of the Kızılırmak delta for a second time by a study conducted by Dik et al. [29], where 246 birds were sampled from the delta. Thirty-three (13.4%) birds were infested with 25 louse species of 20 genera. In the present study, 619 birds belonging to 13 different orders were examined, and 117 of these birds (18.90%) were infested with lice. The sample size of this study was higher compared to previous studies [1, 29]; as a result, more lice species could be detected because of the large sample size.

Adam and Sandor [2] reported that the total number of lice species in Amblycera (13.79%) was less than that in Ischnocera (86.21%). This finding differs from the results of Açıcı et al. [1], who found that Amblyceran lice species (57.95%) were more common on passerines birds of the Kızılırmak delta than Ischnoceran lice species (42.05%).

Order	Family	Genus	Species	SN	IN	Detected louse species
Galliformes	**Phasianidae**	*Coturnix*	*C.coturnix*- Common Quail	2	1	*Goniocotes astrocephalus*
		Phasianus	*P.colchicus*- Common Pheasant	1	1	*Lipeurus caponis**
Pelecaniformes	**Ardeidae**	*Ixobrychus*	*I.minutus*- Little Bittern*	1	1	*Ardeicola celeris***
Accipitriformes	**Accipitridae**	*Accipiter*	*A.nisus* -Eurasian Sparrowhawk	3	2	*Degeeriella nisus*
		Circus	*C.aeruginosus* -Western Marsh Harrier	1	1	*Colpocephalum turbinatum*
Falconiformes	**Falconidae**	*Falco*	*F. peregrinus* -Peregrine Falcon*	1	-	-
Gruiformes	**Rallidae**	*Crex*	*C.crex* -Corncracke*	2	2	*Rallicola ortygometrae***
Charadriiformes	**Scolopacidae**	*Tringa*	*T.glareola* -Wood Sandpiper	1	1	*Actornitophilus totani*
						Quadraceps obscurus
		Limosa	*L.limosa* -Black-Tailed Godwit*	1	1	*Actornitophilus spinulosus***
						Lunaceps sp. (N)**
Cuculiformes	**Cuculidae**	*Cuculus*	*C.canorus*- Common Cuckoo	1	-	-
Strigiformes	**Strigidae**	*Otus*	*O.scops* -Common Scops-Owl*	1	-	-
Caprimulgiformes	**Caprimulgidae**	*Caprimulgus*	*C.europaeus* -Eurasian Nightjar	2	1	*Mulcticola hypoleucus*
Coraciiformes	**Alcedinidae**	*Alcedo*	*A.atthis* -Common Kingfisher	9	3	*Alcedofulla alcedinis*
	Meropidae	*Merops*	*M.apiaster* -European Bee-Eater	12	12	*Meropoecus meropis*
						Meropsiella apiastri
						Meromenopon meropis
Bucerotiformes	**Upupidae**	*Upupa*	*U.epops* -Eurasian Hoopoe*	3	2	*Menacanthus fertilis***
Piciformes	**Picidae**	*Jynx*	*J.torquilla* - Eurasian Wryneck*	7	4	*Penenirmus serrilimbus***
	Acrocephalidae	*Acrocephalus*	*A.arundinaceus*- Great Reed Warbler	9	-	-
			A. palustris -Marsh Warbler	2	-	-
			A.scirpaceus- Reed Warbler	14	2	*Menacanthus curuccae*
		Hippolais	*H.icterina* -Icterine Warbler*	1	-	-
		Iduna	*I.pallida*- Eastern Olivaceous Warbler*	4	1	*Menacanthus curuccae**
	Aegithalidae	*Aegithalos*	*A.caudatus* – Long-Tailed Tit	5	-	-
	Motacillidae	*Anthus*	*A.campestris*- Tawny Pipit*	1	-	-
			A.trivialis -Tree Pipit*	3	-	-
		Motacilla	*M.flava*- Yellow Wagtail	3	1	*Menacanthus* sp. (N)
	Hirundinidae	*Hirundo*	*H.rustica* -Barn Swallow	9	7	*Brueelia domestica*
						Myrsidea rustica
		Riparia	*R.riparia* -Sand Martin*	1	1	*Myrsidea* sp. (N)**
Passeriformes	**Cettiidae**	*Cettia*	*C.cetti* -Cetti's Warbler	17	-	-
	Emberizidae	*Emberiza*	*E.citrinella* -Yellowhammer*	2	-	-
			E.hortulana -Ortolan Bunting*	6	-	-
	Muscicapidae	*Erithacus*	*E.rubecula*- European Robin	15	1	*Menacanthus* sp. (N)
		Ficedula	*F.albicollis*- Collared Flycatcher*	14	1	*Brueelia* sp.**
			F.hypoleuca- European Pied Flycatcher*	1	-	-
			F.parva- Red-Brested Flycatcher*	13	-	-
			F.semitorquata- Semi-Collared Flycatcher*	1	-	-
		Luscinia	*L.luscinia* -Thrush Nightingale	21	3	*Menacanthus curuccae**
			L.megarhynchos- Common Nightingale	6	-	-
			L.svecica- Bluethroat	2	-	-
		Muscicapa	*M.striata*- Spotted Flycatcher	32	3	*Philopterus desertus***
						Penenirmus sp. (destroyed)**
		Oenanthe	*O.oenanthe* -Northern Wheatear*	2	-	-
		Phoenicurus	*P.ochruros*- Black Redstart*	3	-	-
			P.phoenicurus- Common Redstart	45	-	-
		Saxicola	*S. rubetra*- Whinchat*	3	-	-
			S.rubicola -European Stonechat*	3	-	-
	Fringillidae	*Carduelis*	*C.carduelis* -European Goldfinch	1	-	-
		Coccothraustes	*C.coccothraustes* -Hawfinch*	1	-	-
		Fringilla	*F.coelebs* -Chaffinch	2	-	-
			F.montifringilla -Brambling*	1	1	*Philopterus rapax***
		Spinus	*S.spinus* -Eurasian Siskin*	1	-	-
	Laniidae	*Lanius*	*L.collurio* –Red-Backed Shrike	15	8	*Brueelia cruciata*
						Menacanthus camelinus
	Locustellidae	*Locustella*	*L.fluviatilis* -Eurasian River Warbler	1	-	-
			L.luscinioides- Savi's Warbler	1	-	-
	Oriolidae	*Oriolus*	*O.oriolus* -Eurasian Golden-Oriole	7	7	*Ricinus dolicocephalus***
						Maculinirmus mundus
	Paridae	*Cyanistes*	*C.caeruleus* -Blue Tit	3	-	-
		Parus	*P.major* -Great Tit	5	-	-
	Passeridae	*Passer*	*P.domesticus*- Sparrow	3	1	*Philopterus fringillae*
			P.hispaniolensis -Spanish Sparrow*	19	-	-
	Phylloscopidae	*Phylloscopus*	*P.collybita* -Common Chiffchaff	12	2	*Menacanthus agilis*
						Menacanthus eurysternus
			P.sibilatrix- Wood Warbler	3	-	-
			P.trochilus -Willow Warbler	61	13	*Brueelia* sp. **
						Menacanthus agilis
						M. eurysternus

Table I: Examined bird species, infestation rate, and identified lice species

Order	Family	Genus	Species	SN	IN	Detected louse species
Passeriformes	**Prunellidae**	*Prunella*	*P.modularis*- Hedge Accentor	2	-	-
	Regulidae	*Regulus*	*R.ignicapilla*- Firecrest	2	-	-
			R.regulus- Goldcrest	1	1	*Philopterus reguli***
						*Ricinus frenatus***
	Sturnidae	*Sturnus*	*S.vulgaris*- Common Starling	1	-	-
	Sylviidae	*Sylvia*	*S.atricapilla* -Blackcup	60	5	*Menacanthus curuccae**
			S.borin- Garden Warbler	57	9	*Menacanthus curuccae*
			S.communis -Common Whitethroat	22	2	*Menacanthus curuccae**
			S.curruca –Lesser Whitethroat	5	-	-
			S.melanocephala- Sardinian Warbler	12	2	*Penenirmus* sp.
			S.nisoria -Barred Warbler	11	3	*Menacanthus curuccae**
	Turdidae	*Turdus*	*T.iliacus*- Redwing	1	1	*Ricinus elongatus***
			T.merula -Eurasian Blackbird	17	9	*Menacanthus eurysternus*
						*Ricinus elongatus***
						Brueelia jacobi
						Brueelia merulensis
			T.philomelos -Song Thrush	6	1	*Brueelia marginata***
Total				619	117	

SN: Number of birds sampled; IN: Number of infested birds; N: Nymph; *This lice species has been reported on this bird species in Turkey for the first time; ** This species has been recorded in Turkey for the first time.

Table I: *(continued)*

In addition, Dik et al. [29] reported 21 lice species in Ischnocera, and 11 lice species in Amblycera. Dik et al. [29] also found Ischnocerans to be more common than Amblycerans. In a recent study, a total of 21 lice species were detected, 15 Ischnoceran and 6 Amblycerans. Price et al. [49] mentioned that, among the 4000 lice species described in Phthiraptera, a third of these species are Amblyceran; the rest are Ischnoceran. Most of the species identified in this study were Ischnoceran lice species. Far fewer Amblyceran lice species were detected. On the other hand, Amblyceran lice had lower levels of host specificity than Ischnoceran lice. While *M. curuccae* was detected in 7 different bird species, *M.agilis* and *M. eurysternus* were detected in two different bird species.

Açıcı et al. [1] reported that *Menacanthus* and *Brueelia* were the most prevalent genera from Amblycera and Ischnocera, respectively. In studies performed in the Aras River [23] and Kuyucuk Lake [25], *Menacanthus* species were the dominant lice species among passerines. In another study performed on songbirds, the genera *Philopterus* and *Brueelia* (suborder Ischnocera) were identified, while no species from the suborder Amblycera were observed [28]. Dik et al. [28] detected two *Menacanthus* lice species as well as one species each in *Brueelia* and *Philopterus* in the songbirds that they sampled. Dik et al. [29] reported that the genera *Menacanthus* and *Penenirmus* were prevalent in passerines.

In the current study, most of the examined birds were passerines, which was similar to the results of previous studies [1, 18, 19, 20, 22, 23, 24, 25, 27, 28, 29]. *Menacanthus*, *Brueelia* and *Philopterus* were the dominant genera found on these bird species. There are some lice species that were identified for the first time in *Brueelia*, but these species have not been included in the total number of identified species. Some species [50] previously found in Brueelia were reclassified by morphological and phylogenetic analysis by some researchers [11, 46]. For this reason, some species previously reported by Price et al [50] as *Brueelia munda* (*Maculinirmus mundus*) and *Brueelia apiastri* (*Meropsiella apiastri*) have been removed from *Brueelia*. *Maculinirmus mundus*, which was considered to be synonymous with *Brueelia munda*, and *Meropsiella apiastri*, which was recorded as *Brueelia apiastria*, were not analysed in the *Brueelia genus* detected in this study. In addition, *Brueelia* species were detected for the first time in *Ficedula albicollis* and *Phylloscopus trochilus* and could not be identified at species level. For this reason, these specimens were not included in the number of *Brueelia* identified in this survey. These results are similar to the results of previous studies [1, 29]. Although *Philopterus* were not detected in previous studies, four *Philopterus* species were detected in this study. Because *Penenirmus* specimens collected from *M. striata* and *S. melanocephala* were not identifiable to species, they were not included in *Penenirmus* counts that were made in this study. This omission made the number of species in *Penenirmus* to be underestimated relative to other species.

Menacanthus, *Brueelia*, *Penenirmus* and *Philopterus* appear to be the most common genera identified on passerines in Turkey, whereas *Myrsidea*, *Ricinus* and *Sturnidoecus* appear to be less common. *Menacanthus* was present on many species parasitizing birds of Passeriformes, Piciformes, Tinamiformes and Galliformes [48]. The *Brueelia*-complex consists of a tenth of all known Phthiraptera species, while more than 300 species are included in the genus *Brueelia* sensu stricto [11]. The *Philopterus* complex is one of largest lice groups in Phthiraptera: This complex has 11 genera and was detected in, more or less, all passerines. The *Philopterus* complex has been identified in four families in the other orders, in addition to Passeriformes. Species of this complex infest approximately 5000 bird species of 94 families [45].

Several authors have suggested that birds of large size can carry more lice than small-sized birds [29, 35, 36, 42, 52]. However, Galloway and Palma [35] reported that pigeons sampled in Manitoba, Canada were infested with 1-2416 lice

and that the mean lice density per bird was 97.3. In studies performed in Turkey, lice infestation in Passeriformes was less common compared to other bird orders [23, 25, 27, 28, 29]. The infestation rate on birds belonging to Anseriformes, Accipitriformes, Pelecaniformes, Galliformes, Charadriiformes and Ciconiiformes were generally higher [20, 33, 38, 39, 41].

Birds were captured in mist-nests of 16-mm mesh size, which is suitable for catching small-sized birds, such as passerines. The mesh size may explain why most of the captured birds were passerines (571 birds out of 619 total). Numbers of sampled birds were scarce in other orders. For this reason, infestation rate in Gruiformes, Pelecaniformes and Charadriiformes was 100%, while in Falconiformes, Cuculiformes and Strigiformes, the infestation rate was 0%. These results could not be statistically analysed for significance due to the small sample size.

Some authors have reported more than 10 different lice species on the same bird. [50, 58]. However, in the current study, the number of louse species found on single birds varied from one to three: one species was found on 88 birds; two different species were found on 11 birds; and three different species were found on 4 birds. Among the 12 European Bee-eaters (*Merops apiaster*) that were examined, four of them were infested with three lice species. This result is consistent with previous studies where the species *Meropsiella apiastri* (*Brueelia apiastri*), *Meromenopon meropis*, and *Meropoecus meropis* have been detected [2, 3, 30, 50]. Dik et al. [29] reported the louse density to be higher in Eagle Owl (*Bubo bubo*) [23], Rock Dove (*Columba livia*) [9] Long-legged Buzzard (*Buteo rufinus*) [16] and Common Buzzard (*Buteo buteo*) [13]. In a study that lasted for 22 years in Canada, 19% of the sampled Common Nighthawks (*Chordeiles minor*) were found to be infested with 66 lice (*Mulcticola macrocephalus*, Kellogg) each. The remaining sampled birds had 1 to 10 lice each; the mean lice density was 7.9 lice per bird [36]. In our study, an average of less than 10 lice per bird were collected from each bird. However, Quadraceps obscurus collected from the Wood Sandpiper (*Tringa glareola*) and *Menacanthus eurysternus* collected from the Blackbird (*Turdus merula*) were found to be more than 100. The Marsh Harrier (*Circus aeruginosus*) and the Golden Oriole (*Oriolus oriolus*) were the next most infested with 43 lice specimens. The next highest was the European Bee-eater, with 36 lice specimens each, and the Red-backed Shrike (*Lanius collurio*), with 24 lice specimens. Only one louse specimen (*M. hypoleucus*) was found on the Nightjar (*Caprimulgus europaeus*) in this study. Sychra et al. [54] reported that the number of lice on each bird ranged from 1 to 11 and that the mean lice intensity was 2.3-4.8 per bird in Slovakia, Czech Republic, England and Faroe Islands. In that study, the prevalence of *M. curuccae* was reported to be 7.9-20% on the Reed Warbler (*A. scirpaceus*). Previous studies in Turkey have found that the lice infestation rate is lower in Passeriformes, with an infestation rate from 2.45% to 21.57% [23, 25, 28]. In our study, 15.06% of the 571 passerines sampled were infested. The average lice density was low and ranged from 1 to 7 in Passerines, except in the Blackbird (1-74), Golden Oriole (1-43) and Red-backed Shrike (1-24). Seven lice were collected from the Willow Warbler (*Phylloscopus trochilus*), 6 from the Yellow Wagtail (*Motacilla flava*) and 6 from the Garden Warbler (*Sylvia borin*). In a study performed in Ukraine, lice infestation rate was found to be 58.2% in Passeriformes; lice were found in Sturnidae, Corvidae, Ploceidae, Hirundinidae and Laniidae [33]. In Romania, the infestation rate of passerines was low overall but was higher in Prunellidae, Turdidae and Sittidae [2].

Dik et al. [23] detected infested birds only in two species out of 27 Phylloscopidae species. Among passerines high infestation rates were found in Emberizidae (100%) and Hirundiniade (28.6%) but were lower in Muscicapidae (8.69%), Phylloscopidae (5.55%), Sylviidae (5.21%) and Cettidae (4.54%)[29]. In the present study, louse infestation rate was the lowest in Acrocephalidae and Muscicapidae and, in the 45 Redstarts (*P. phoenicurus*) that were examined, no lice were detected. In contrast, infestation rates were quite high in Oriolidae, Turdidae, Laniidae, and Hirundinidae. Because the bird species that were sampled were not distributed equally among families, the results could vary significantly and should be interpreted with caution. The disproportionate distribution of birds among families lead to an infestation ratio of 100% in families for which there was only one bird sampled. Such low sample sizes can bias analyses of infestation rate because the number of sampled birds should be comparable among families before testing for statistical significance. On the other hand, other methods, such as the use of insecticides and visual examinations, are subject to their own biases. While infestation rate on insecticides-used birds was higher [23, 25], infestation rate was lower in visually examined birds [28, 29].

Macroscopic visual examinations are prone to overlooking nymphs and lice species that camouflage well with bird feathers. Additionally due to fast movements of Amblyceran species the probability to overlook them is quite high [44]. Some birds are difficult to handle due to their size, behaviour, and density of their feathers. Therefore, the use of synthetic pyrethroides has been proposed by some authors to facilitate the harvesting of lice [16]. The use of insecticides will directly affect estimates of infestation rate and sample size.

So far, more than 200 bird species have been examined for lice infestation in Turkey. These efforts have led to variable results. Twenty-six bird species have been examined for the first time in Turkey for the presence of lice in this study (see: Table 1). In addition, 18 lice species were recorded for the first time from Turkey, and 6 lice species were recorded for the first time on new hosts in Turkey.

In this study, 73 out of the 350 bird species previously recorded in the Kızılırmak delta were examined for the presence of lice. Passerines were the most common birds. Similarly bird species numbers examined for lice infestation

reached up to 250 species in Turkey with this research. Considering that 482 bird species have been recorded in Turkey, there are still several bird species that need to be examined for lice and several new lice species that could be added to the lice fauna of Turkey. Studies conducted at new locations in Turkey likely have the highest probability of generating new records. Thus, the lice fauna of Turkey is likely to grow as more research is conducted.

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