

In summary, this is the first report of *E. lancasterensis* and *E. ontarioensis* from fox squirrels in Nebraska, thus extending the known geographic range for these parasites. Given that the reported prevalence values for *E. lancasterensis* are consistently high, we predict that it will be found in high prevalence in other populations of eastern grey squirrels and fox squirrels.

This project is part of an ongoing study of the parasites of the fox squirrel in southeastern Nebraska and northeastern Kansas. Acknowledgments are due to National Science Foundation Grant No. 9705179 and the Peru State College Foundation.

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#### Research Note

### Chewing Louse Distributions on Two Neotropical Thrush Species

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**ABSTRACT:** We sampled lice from 2 species of Neotropical thrushes, *Turdus assimilis*, the white-throated robin, and *T. grayi*, the clay-colored robin, to docu-

ment the prevalence, intensity, abundance, and species richness on each host. Sampling was conducted in 1999 in the Coto Brus Valley of southern Costa Rica using a modified dust-ruffling technique. The prevalence of lice was high—lice were recovered from 93% ( $n = 14$ ) of *T. grayi* and 86% ( $n = 22$ ) of *T. assimilis*

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individuals sampled. Observed prevalence and generic-level louse diversity were similar to those reported for *T. migratorius*, the American robin, in Newfoundland, Canada, although *T. assimilis* and *T. grayi* tended to have higher proportions of lice belonging to the sub-order Amblycera. *Turdus grayi* hosted marginally more louse species (mean = 1.6, SD = 0.8) and had marginally higher louse abundance (mean = 33.9, SD = 27.9) than *T. assimilis* (mean = 1.1, SD = 0.6 and mean = 16.5, SD = 17.3, respectively), although *T. grayi* and *T. assimilis* are closely related and similar in size. Distributions of lice on the 2 species were aggregated, indicating substantial individual variation in the abundance of lice supported.

KEY WORDS: chewing lice, phthiraptera, white-throated robin, *Turdus assimilis*, clay-colored robin, *Turdus grayi*, Costa Rica.

Parasitism may influence fitness (e.g., Clayton et al., 1999), life-history strategies (e.g., Møller, 1997), mate choice (e.g., Lopez, 1999), and population dynamics (e.g., Forchhammer and Asferg, 2000); yet, our knowledge of common parasites infecting Neotropical bird species is extremely limited (Clayton et al., 1992). In this article, we present information on the prevalence, intensity, abundance, and species richness of avian chewing lice (Insecta: Phthiraptera) on 2 species of resident Neotropical thrushes, *Turdus assimilis*, the white-throated robin, and *T. grayi*, the clay-colored robin. These are the first quantitative data on the louse fauna of these 2 species. We compare our results with those of Wheeler and Threlfall (1986) for *T. migratorius*, the American robin. We also present data on sex and age ratios of the lice to compare with other data on bird louse suprapopulations. The work was conducted in the Coto Brus Valley of southern Costa Rica.

Clay-colored and white-throated robins eat insects and fruit, spending time foraging on the ground as well as in vegetation. Clay-colored robins are common in cleared areas of Costa Rica. They inhabit urban and agricultural habitats and occasionally enter forests (Morton, 1983; Stiles and Skutch, 1989). White-throated robins also use open habitats to some extent but use forest habitats more extensively than do clay-colored robins. White-throated robins have nearly disappeared from the Central Valley of Costa Rica, probably because of the extensive deforestation in this area (Stiles and Skutch, 1989). Both species have relatively large geographic ranges that extend from Mexico into

South America. White-throated robins are altitudinal migrants, although their movement patterns are poorly known (Stiles and Skutch, 1989).

Chewing lice may complete their life cycle on 1 host individual. They feed on feathers, blood, and dermal debris of the birds they inhabit (Marshall, 1981). They are classified into the sub-orders Amblycera and Ischnocera. Amblycerans are generally more active and move faster than Ischnocerans (Ash, 1960) and sometimes leave their hosts when the host is disturbed or dying. Ischnocerans are apparently dependent on direct contact for dispersal to another host or on phoresy, which occurs when lice attach to other animals such as hippoboscids for transportation to other hosts (Marshall, 1981).

We collected lice from adult white-throated and clay-colored robins during February, March, and June of 1999, dates that correspond to just before and during the breeding season for both bird species. We collected lice near the Las Alturas Biological Station (8°57'N; 82°50'W) and the Las Cruces Forest Reserve (8°45'N; 82°55'W) in southern Costa Rica. The sites are approximately 25 km apart on the Pacific slope of the country. Elevations at Las Alturas range from 1,300 to 1,500 m and at Las Cruces from 1,100 to 1,300 m. Collection at Las Alturas took place in the primary forest of the Las Tablas Protected Area and in a coffee plantation about 1 km from the forest site. Collection at Las Cruces took place in the Las Cruces Forest Reserve as well as in several forest fragments within 2 km of the Reserve. We used passive mist-netting to capture individuals of both species.

When individuals were first captured they were banded with metal and plastic leg bands so that we could recognize recaptures. We took several morphological measurements, including weight, and then followed a modified dust-ruffling technique to collect lice (Walther and Clayton, 1997). We spread a heaping thimbleful ( $\approx 2$  g) of Cardinal Flea and Tick Powder throughout each bird's feathers on all parts of the body. This brand of flea powder contains 0.1% pyrethrin, an insecticide that is not harmful to birds or mammals (Casida, 1973; Clayton and Tompkins, 1995). After spreading the powder, we put each bird in a paper bag closed with a clip. We removed the bird after 10 min and then gently ruffled its feathers for 3 min over a large shallow pan. We released the bird, collected all the lice

**Table 1. Prevalence and intensity of 4 louse genera (*Menacanthus*, *Myrsidea*, *Sturnidoecus*, and *Brueelia*) on *Turdus grayi* and *Turdus assimilis*.**

Host	Louse	Hosts (n)	Infected hosts	Prevalence	Intensity	
					Mean $\pm$ SD	Range
<i>T. grayi</i>	<i>Me. eurysternus</i>	14	3	21	26.0 $\pm$ 16.1	21–44
<i>T. grayi</i>	<i>My. carrikeri</i>	14	11	79	30.6 $\pm$ 24.8	1–69
<i>T. grayi</i>	<i>S. caliginus</i>	14	8	57	2.6 $\pm$ 1.9	1–6
<i>T. assimilis</i>	<i>Me. eurysternus</i>	22	2	9	8.5 $\pm$ 9.2	2–15
<i>T. assimilis</i>	<i>Myrsidea</i> sp.	22	17	77	18.1 $\pm$ 15.3	1–48
<i>T. assimilis</i>	<i>Sturnidoecus</i> sp.	22	4	18	2.3 $\pm$ 1.9	1–5
<i>T. assimilis</i>	<i>Brueelia</i> sp.	22	2	9	10.5 $\pm$ 7.8	5–16

that had fallen into the paper bag or into the pan, and put the lice in 70% ethyl alcohol.

All specimens were mounted on microscope slides by Michigan State University personnel and were identified by R.P. Several specimens were deposited at the National Museum in San José, Costa Rica, and voucher specimens have been deposited with the Department of Entomology at the National Museum of Natural History, Smithsonian Institution (accession number TM 2023094). When the data did not meet the normality assumption required by parametric statistical tests, such as the *t*-test, we used non-parametric tests for analyses, including the Mann–Whitney *U*-test and *G*-tests of goodness of fit. We calculated William's correction for all *G*-tests of goodness of fit (Sokal and Rohlf, 1995).

We sampled 7 louse suprapopulations, 3 from clay-colored robins and 4 from white-throated robins. Of these 7, 3 had at least 10 females and 10 males, which we considered as the minimum number to test for biased sex ratios. These 3 suprapopulations were also the only ones with at least 10 adults and 10 immatures, allowing us to test for biased age ratios. For the *G*-tests of goodness of fit that we used to test for biased age or sex ratios, we used a sequential Bonferroni procedure to adjust for the increased probability of observing statistical significance for any single test, when multiple tests of the same hypothesis are conducted (Rice, 1989). The use of the terms prevalence, mean abundance, mean intensity, and suprapopulation is consistent with the definitions of Bush et al. (1997).

We collected lice from 22 white-throated robins and 14 clay-colored robins. The mean weights of the individuals of the 2 bird species were similar (white-throated robins, 63.6 g

[ $\pm$ 5.0 SD],  $n = 22$ ; clay-colored robins, 66.2 g [ $\pm$ 5.7 SD],  $n = 14$ ;  $T = 1.44$ ,  $P = 0.16$ ). Mean louse abundance for the 2 robin species was not significantly different between the 2 main time periods when lice were collected (February–March 1999 and June 1999; Mann–Whitney *U*-tests: white-throated robins,  $U = 51.0$ ,  $P > 0.1$ ; clay-colored robins,  $U = 12.0$ ,  $P > 0.1$ ). Hence, we combined the data from the 2 periods for all analyses.

We collected 363 lice from 22 white-throated robins. Nine of the 363 lice were lost or became unidentifiable during the slide-mounting procedure. We collected 475 lice from 14 clay-colored robins, with a processing loss of 39 lice. Prevalence of lice on white-throated robins was 86% (95% CI, 65% to 97%). Louse prevalence on clay-colored robins was 93% (95% CI, 66% to 100%).

Three species of lice were collected from clay-colored robins, *Menacanthus eurysternus*, *Myrsidea carrikeri*, and *Sturnidoecus caliginus*. Four species occurred on white-throated robins of which 3 could be assigned to genus only, *Me. eurysternus*, *Myrsidea* sp., *Sturnidoecus* sp., and *Brueelia* sp. Distributions of louse species on host individuals are given in Table 1. Louse prevalence by suborder on host species is presented in Table 2.

The mean louse species richness per bird for the clay-colored robins, including the 1 uninfected individual, was marginally higher (mean = 1.6  $\pm$  0.8 SD) than the mean number of species for the white-throated robins (mean = 1.1  $\pm$  0.6 SD; Mann–Whitney *U*-test,  $U = 104$ ,  $P = 0.07$ ). The mean abundance of lice on the clay-colored robins was also marginally higher (mean = 33.9  $\pm$  27.9 SD) than that for the

**Table 2. Prevalence of lice in the suborders Amblycera and Ischnocera on 3 species of *Turdus*.**

Host	Amblycera (%)	Ischnocera (%)
<i>T. grayi</i>	85.7	57.1
<i>T. assimilis</i>	81.2	27.3
<i>T. migratorius</i> *	11–17	56–83

\* Data from Wheeler and Threlfall (1986). Percentages are given as a range because data presented were numbers of host individuals infected by particular louse species. Which individuals, if any, were infected by more than 1 species was not reported.

white-throated robins (mean =  $16.5 \pm 17.3$  SD, Mann–Whitney  $U$ -test,  $U = 101$ ,  $P = 0.08$ ).

Wheeler and Threlfall (1986) reported the mean intensity of louse infection for American robins (mean =  $24.6 \pm 26.5$  SD, variance = 702.3) rather than the mean abundance. To enable comparison, we report these measures here. For clay-colored robins, the mean intensity of infection was  $36.5 \pm 27.2$  SD (variance = 739.8), and for white-throated robins, it was  $19.1 \pm 17.2$  SD (variance = 295.8).

Numbers of adult males, adult females, and immature lice recovered from each of the 7 suprapopulations of lice sampled (7 louse species over 2 host species) are presented in Table 3. Of the 3 suprapopulations with at least 10 females and 10 males, only *My. carrikeri* on clay-colored robins had a significantly female-biased sex ratio ( $G$ -test of goodness of fit with sequential Bonferroni procedure,  $P < 0.05$ ). The sex ratios of the other 2 suprapopulations, *Me. eurysternus* on clay-colored robins and *Myrsidea* sp. on white-throated robins, were not significantly biased ( $G$ -test of goodness of fit with sequential Bonferroni procedure,  $P > 0.05$  in both cases).

None of these 3 suprapopulations, each comprising at least 10 adults and 10 immatures, had significantly skewed age ratios ( $G$ -tests of goodness of fit with sequential Bonferroni procedure, all  $P$  values  $> 0.05$ ).

Almost all clay-colored robins (93%) and white-throated robins (86%) were infected with lice. Of 18 American robins sampled in Newfoundland, Canada (Wheeler and Threlfall, 1986), the prevalence was 61%, although this is likely an underestimate. The investigators collected lice using fumigant jars, which exclude a bird's head during sampling and obtain only 80% to 90% of the lice inhabiting a bird (Fowler and Cohen, 1983). We believe that the dust-ruffling method removes a higher percentage of lice because it also includes a bird's head during sampling. Hence, the prevalence of lice on the 2 tropical thrush species may be higher than that reported for the American robins, although differences in the sampling technique preclude a definitive conclusion.

The intensity of infection and abundance of lice varied a great deal among individuals of the 2 tropical thrush species as well as American robins. Louse distributions of all 3 host species were aggregated or clustered (variance/mean  $> 1$ ) (Zar, 1996). Aggregated distributions have been reported frequently for macroparasites (see references in Loye and Zuk [1991] and Hudson and Dobson [1997]), reflecting the pattern of many hosts with low parasite intensities and a few hosts with high parasite intensities.

Although differences were not significant at the  $P = 0.05$  level, there was a trend toward clay-colored robins supporting more louse species ( $P = 0.07$ ) and having a higher louse mean abundance ( $P = 0.08$ ) than white-throated robins, suggesting interspecific variation for these

**Table 3. Numbers of adult females, adult males, and immatures for 7 suprapopulations of the louse genera *Menacanthus*, *Myrsidea*, *Sturnidoecus*, and *Brueelia* on *Turdus grayi* and *Turdus assimilis*.**

Host	Louse	Adult females	Adult males	Immatures	Females $\div$ males	Adults $\div$ immatures
<i>T. grayi</i>	<i>Me. eurysternus</i>	24	12	42	2.0	0.9
<i>T. grayi</i>	<i>My. carrikeri</i>	93	65	179	1.4	0.9
<i>T. grayi</i>	<i>S. caligineus</i>	4	1	16	4.0	0.3
<i>T. assimilis</i>	<i>Me. eurysternus</i>	5	1	11	5.0	0.5
<i>T. assimilis</i>	<i>Myrsidea</i> sp.	85	70	152	1.2	1.0
<i>T. assimilis</i>	<i>Sturnidoecus</i> sp.	5	1	3	5.0	2.0
<i>T. assimilis</i>	<i>Brueelia</i> sp.	11	8	2	1.4	9.5

measures. The 2 robin species are essentially of the same size and closely related, suggesting that the greater species richness on the clay-colored robins is not a result of greater area or habitat heterogeneity (or both) on that species, factors that sometimes explain species richness differences between habitats (Simberloff and Moore, 1997). However, ecological and habitat utilization differences among robin species that alter host physiological stability or contact rates may be related to differences in louse species richness. Louse species richness and mean abundance were positively correlated in a recent study of Neotropical birds (Clayton and Walther, 2001), suggesting that factors influencing one of these statistics probably affect the other, either directly or indirectly.

The 4 genera of lice collected from white-throated robins were also collected from American robins by Wheeler and Threlfall (1986). Patterns of louse prevalence by suborder differed: greater percentages of Amblycerans and lower percentages of Ischnocerans infected tropical robins when compared with the infection in American robins (Table 2). These patterns merit additional study.

*Menacanthus eurysternus* was detected from American robins, clay-colored robins, and white-throated robins, although not from the majority of individuals of any host species. *Menacanthus eurysternus* has been reported from over 120 species of birds (Price, 1975). Hence, it has an extremely widespread, if patchy, distribution.

Our data on louse sex ratios concur with previous work; when a bias exists, it tends to be in favor of females (Wheeler and Threlfall, 1986; Clayton et al., 1992). We found no evidence of biased age ratios, unlike other studies that detected adult-biased ratios (Wheeler and Threlfall, 1986; Clayton et al., 1992).

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### Research Note

## Species of *Dactylogyrus* (Monogenoidea: Dactylogyridae) and *Trichodina mutabilis* (Ciliata) Infesting Koi Carp, *Cyprinus carpio*, During Mass Mortality at a Commercial Rearing Facility in Utah, U.S.A.

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**ABSTRACT:** A die-off of koi carp, *Cyprinus carpio*, at a commercial rearing facility located in Spanish Fork, Utah, U.S.A., is reported. Although the cause of mortality in carp remained undetermined, moribund carp became heavily infested with *Trichodina mutabilis* and 6 species of *Dactylogyrus* (prevalence = 100%). *Dactylogyrus formosus* comprised the largest proportion of the dactylogyrid population on infested hosts (38.7%), followed by *D. dulkeiti* (28.8%), *D. anchoratus* (14.7%), *D. baueri* (8.6%), *D. intermedius* (8.0%), and *D. minutus* (1.2%). Occurrences of *D. dulkeiti* and *D. baueri* on *Cy. carpio* represent new host records. *Dactylogyrus dulkeiti* and *T. mutabilis* on carp in Utah are the first records of these species in the Nearctic.

**KEY WORDS:** Koi carp, Monogenoidea, Dactylogyridae, *Cyprinus carpio*, *Dactylogyrus formosus*, *Dactylogyrus dulkeiti*, *Dactylogyrus anchoratus*, *Dactylogyrus baueri*, *Dactylogyrus intermedius*, *Dactylogyrus minutus*, *Trichodina mutabilis*, Utah.

During the summer of 2000, an episode of mass mortality of koi carp, a colorful variety of the common carp, *Cyprinus carpio*, occurred in a commercial fish farm located in Spanish Fork, Utah County, Utah, U.S.A. (40°06'N; 111°40'W). Before the die-off, the owner of the facility

was given 25 large koi carp (each greater than 30 cm long) by a neighbor who had maintained the fish in California (3 yr) and then in Utah (3 yr) before donating them to the facility. These fish were added to a 0.1-ha pond that had an original population of approximately 110 small- to medium-sized ornamental carp. A dozen koi carp (each about 7.5 cm in length) purchased from a Salt Lake City supplier, who had obtained them from California, were also added to the pond. All of the large koi carp were lost, and approximately 50% of the medium to small fish in the pond died during the 2-mo episode.

Fifteen moribund fish from the fish farm were sent to the laboratory of RH at the Brigham Young University for diagnosis. The liver, gill, spleen and subcutaneous tissue of the fish were examined for viral infections using standard techniques of transmission electron microscopy; the gills and internal organs of 5 of the 15 hosts were also examined for other parasites using standard necropsy methods. Helminth parasites were mounted individually on slides using Gray & Wess' medium (Humason, 1979). Identification of helminths was based on information provided by Gusev (1985). Klein's dry silver impregnation method (see Lom and Dykova

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