Serendipity with chewing lice (Phthiraptera: Menoponidae, Philopteridae) infesting rock pigeons and mourning doves (Aves: Columbiformes: Columbidae) in Manitoba, with new records for North America and Canada

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Abstract—An extensive survey of chewing lice from rock pigeon, *Columba livia* Gmelin, and mourning dove, *Zenaida macroura* (L.), carried out from 1994 to 2000 and from 2003 to 2006 in Manitoba, Canada, produced the following new records: *Coloceras tovornikae* Tendeiro for North America; *Columbicola macrourae* (Wilson), *Hohorstiella lata* (Piaget), *H. paladinella* Hill and Tuff, and *Physconelloides zenaidurae* (McGregor) for Canada; and *Bonomiella columbae* Emerson, *Campanulotes compar* (Burmeister), *Columbicola baculoides* (Paine), and *C. columbae* (L.) for Manitoba. We collected 25 418 lice of four species (*C. compar*, *C. columbae*, *H. lata*, and *C. tovornikae*) from 322 rock pigeons. The overall prevalence of infestation was 78.9%, 52.5%, and 23.3% for *C. compar*, *C. columbae*, and *H. lata*, respectively. *Coloceras tovornikae* was not discovered until 2003, after which its prevalence was 39.9% on 114 pigeons. We collected 1116 lice of five species (*P. zenaidurae*, *C. baculoides*, *C. macrourae*, *H. paladinella*, and *B. columbae*) from 117 mourning doves. *Physconelloides zenaidurae* was encountered most often (prevalence was 36.7%), while the prevalence of the other four species was 26.3%, 18.4%, 3.5%, and 2.6%, respectively.

Résumé—Une étude approfondie de poux mâcheurs sur des pigeons bisets, *Colomba livia* Gmelin, et des tourterelles tristes, *Zenaida macroura* (L.), effectuée de 1994 à 2000 et de 2003 à 2006 au Manitoba, Canada, a produit les nouvelles mentions suivantes : *Coloceras tovornikae* Tendeiro pour l'Amérique du Nord; *Columbicola macrourae* (Wilson), *Hohorstiella lata* (Piaget), *H. paladinella* Hill et Tuff et *Physconelloides zenaidurae* (McGregor) pour le Canada; et *Bonomiella columbae* Emerson, *Campanulotes compar* (Burmeister), *Columbicola baculoides* (Paine) et *C. columbae* (L.) pour le Manitoba. Nous avons rassemblé 25 418 poux de quatre espèces (*C. compar*, *C. columbae*, *H. lata* et *C. tovornikae*) sur 322 pigeons bisets. La prédominance globale était 78,9 %, 52,5 % et 23,3 % pour *C. compar*, *C. columbae* et *H. lata*, respectivement. *Coloceras tovornikae* n'a pas été découvert avant 2003, après quoi sa prédominance de l'infestation était 39,9 % sur 114 pigeons bisets. Nous avons rassemblé 1116 poux de cinq espèces (*P. zenaidurae*, *C. baculoides*, *C. macrourae*, *H. paladinella* et *B. columbae*) sur 117 tourterelles tristes. *Physconelloides zenaidurae* a été trouvé plus fréquemment (prédominance était 36,7 %), alors que la prédominance pour les quatre autres espèces était 26,3 %, 18,4 %, 3,5 % et 2,6 %, respectivement.

Introduction

Chewing lice (Phthiraptera: Menoponidae, Philopteridae) of Columbiformes in North America have been the subject of numerous taxonomic studies, and the species are reasonably well known (*e.g.*, Emerson 1957*a*, 1957*b*, 1960; Emerson and Ward 1958; Hill and Tuff 1978; Clayton and Price 1999; Price *et al*. 1999). The domestic pigeon or rock pigeon (*Columba livia* Gmelin), in particular, is widely spread as a result of dispersal by human, and has carried many

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lice along with it on its global travels (*e.g.*, Nelson and Murray 1971; Pilgrim 1976; Dranzoa *et al*. 1999; Toro *et al*. 1999). Because of the abundance of some of the rock pigeon lice and the ease of captive breeding and handling of the host and its lice, they have been used to conduct many detailed studies on biology, ecology, and evolution (*e.g.*, Martin 1934; Stenram 1956; Nelson and Murray 1971; Clayton 1990; Clayton 1991; Moyer *et al*. 2003; Bush *et al.* 2006).

The columbiform fauna of Manitoba is quite limited, including only two species that now breed regularly in the province. The rock pigeon is important as a peridomestic species and to pigeon fanciers, and as a reservoir of organisms potentially pathogenic to humans (Johnston 1992). It is very abundant around human habitation, and some of its highest densities recorded during Christmas bird counts in North America have been in Manitoba. The mourning dove (*Zenaida macroura* (L.)) is an important game species in the United States of America, and is one of the most abundant species of birds in North America (Mirarchi and Baskett 1994). It breeds commonly across southern and western Manitoba and has been sighted into the far northern regions of the province (Holland and Taylor 2003). The passenger pigeon (*Ectopistes migratorius* (L.)) was once abundant in Manitoba but is now extinct. Two additional species, the band-tailed pigeon (*Columba fasciata* Say) and the white-winged dove (*Zenaida asiatica* (L.)), have been recorded in the province as rare visitors (Koes 2003; Taylor 2003).

Although Price *et al*. (2003) reported 12 species of chewing lice on the ubiquitous rock pigeon, only three species have been reported in Canada: *Bonomiella columbae* Emerson (Menoponidae) from British Columbia (Emerson 1957*b*), *Campanulotes compar* (Burmeister) (Philopteridae) from Alberta (Brown and Wilk 1944) and Quebec (Raynor 1932; Whitehead 1934, 1954), and *Columbicola columbae* (L.) (Philopteridae) from British Columbia (Spencer 1928, 1948, 1957), Alberta (Brown and Wilk 1944), Ontario (Stirrett 1952), and Quebec (Raynor 1932; Thompson 1934; Whitehead 1934, 1954). The rock pigeon is very common in southern Canada and there are many unpublished records for these lice in various collections; however, no one has gathered the information together. There is only one published record of a chewing louse from *Z. macroura* in Canada: *Columbicola baculoides* (Paine), from British Columbia (Spencer 1957), although five species are known to infest this host elsewhere (Price *et al*. 2003). No one has conducted a consistent, intensive survey of chewing lice on pigeons in Canada.

As part of a survey on ectoparasites of birds in Manitoba, we examined rock pigeons and mourning doves first in 1994. Since no new lice were discovered, sampling effort was reduced during 1999–2002. In 2003, at the request of a colleague, a few rock pigeons were examined for lice. To our considerable surprise, the first pigeon examined was infested with a species of *Coloceras* Taschenberg (Philopteridae) not seen in previous samples, and in fact, a genus not previously known to occur on domestic pigeons in North America (Johnson and Clayton 2003). The species is, in our opinion, *C. tovornikae* Tendeiro. We provide a description of the previously unknown male of this species and discuss the ramifications of its discovery in North America. After this serendipitous discovery, intense sampling of rock pigeons was resumed to obtain as much information about this newly discovered chewing louse as possible. Here we report on the species of chewing lice found over a span of 12 years on the two most abundant species of columbiforms in Manitoba, along with their respective infestation parameters.

Materials and methods

Birds were salvaged from a number of sources under scientific collecting permits issued by Manitoba Conservation and the Canadian Wildlife Service. Most came from the hospital of the Manitoba Wildlife Rehabilitation Organization (now Wildlife Haven) at the Glenlea Research Station (University of Manitoba Faculty of Agricultural and Food Sciences), Glenlea, Manitoba. A few birds were found dead and submitted by members of the public. No attempt was made to sex or age the birds. Each bird was individually bagged immediately after death and frozen to kill all ectoparasites. Chewing lice were collected from about 30 rock pigeons and 27 mourning doves early in the survey (1994–1995) by ruffling the feathers of each over a white enamel pan. Subsequently examined birds were washed in warm soapy water and ectoparasites were collected using methods described in Mironov and Galloway (2002). Data from ruffled birds are combined with data from washed birds, with no discrimination in the analysis of prevalence of infestation. It is understood that data from

ruffled birds constitute an underestimate of intensity of infestation for those birds (Clayton and Drown 2001; T.D. Galloway, unpublished data), so in comparisons of intensity of infestation among rock pigeons for different time periods, only data from washed birds are included. Ectoparasites were preserved in 70% ethanol, and slides of representative specimens were made throughout the study using the method described by Richards (1964). Prevalence (percentage of hosts infested) and mean intensity (mean number of lice per infested host) are reported for total infestations and infestation by each species of louse. Calculations and comparisons of infestation parameters were conducted using Quantitative Parasitology 3.0, according to Rózsa *et al.* (2000).

A variety of lice other than those that specifically parasitize rock pigeons and mourning doves were collected, and lice that typically infest columbiforms were occasionally collected on unrelated hosts. These lice are considered stragglers or contaminants as defined by Pilgrim and Palma (1982: p. 2).

Voucher specimens are deposited in the J.B. Wallis Museum of Entomology (Department of Entomology, University of Manitoba, Winnipeg, MB R3T 2N2), the Museum of New Zealand Te Papa Tongarewa (Wellington, New Zealand), and the Canadian National Collection (Agriculture and Agri-Food Canada, Ottawa, ON K1A 0C6).

Results

Columba livia

A total of 322 rock pigeons were sampled during this study, the majority of which were known to come from the city of Winnipeg, Manitoba (n = 282). Birds from known localities in Manitoba came from Glenlea (n = 3), Portage la Prairie (n = 2), and one each from Ste. Agathe, Landmark, Îles des Chênes, and La Salle. The remaining 31 birds came from unknown localities in Manitoba. The following numbers of birds were examined in each year of the survey: 10 in 1994, 34 in 1995, 7 in 1996, 48 in 1997, 10 in 1998, 0 in 1999, 5 in 2000, 0 in 2001; 0 in 2002, 27 in 2003, 126 in 2004, 38 in 2005, and 17 in 2006. Birds were sampled in all months of the year. A disproportionate number of birds were examined in February 2004 (48), largely as a result of an apparent paramyxovirus enzootic in rock pigeons from Winnipeg (most had died or were euthanized as a result of severe infection).

A total of 25 418 lice of four species were found infesting rock pigeons in Manitoba: *Columbicola columbae*, *Campanulotes compar*, *Hohorstiella lata* (Piaget) (Menoponidae), and *Coloceras tovornikae*. For the total sample of 322 birds, the prevalence of infestation by all species was 81.4% (95% confidence interval = 76.7–85.5) and the mean intensity was 97.3 (range = 1–2416, 95% bootstrap confidence interval = 78.6–125.9). The distribution of total lice on pigeons did not conform to the negative binomial distribution (variance/mean = 418.3, D = 0.725). Of the total birds sampled, 64 (19.9%) were infested with only one species of louse, and of these, 57 (89.1%) were infested with *C. compar*. There were 101 birds (31.4%) infested with two species of lice, 76 (23.6%) infested with three species of lice, and 21 (6.5%) infested with four species of lice.

However, analysis of the overall infestation parameters for rock pigeons was divided into two periods based on the nature of sampling and on the discovery of *C. tovornikae* infesting pigeons in 2003. The first period was 1994–2000, when 114 birds were examined. The prevalence of infestation by chewing lice was 56.1% (95% confidence interval = 46.5–65.4), where the mean intensity for all birds was 50.4 (range = 1–292, 95% confidence interval = 36.6–69.3). For the subsequent period of sampling, 2003–2006, 208 birds were examined, in which the prevalence of infestation was 94.7% (95% confidence interval = 90.7–97.3) and the mean intensity was 112.6 (range = 1–2416, 95% confidence interval = 90.4–158.6). The prevalence and mean intensity of infestation were greater ($P < 0.05$, Fisher's exact test for comparing prevalences and bootstrap two-sample t test for comparing mean intensities) during the 2003–2006 sampling period. In neither 1994–2000 (variance/mean = 113.3, D = 0.729) nor 2003–2006 (variance/mean = 445.2, D = 0.672) did the distribution of total lice conform to a negative distribution.

Campanulotes compar

Overall this was the most frequently collected chewing louse on rock pigeons, occurring on 254 of 322 birds (78.9%; 95% confidence interval = 74.0–83.2), with a mean intensity for all birds of 49.0 (95% confidence interval = 40.2–60.0, range = 1–655). However, the prevalence and intensity (the latter for washed birds only) of infestation were

significantly higher in 2003–2006 than they were in 1994–2000 (Table 1). The distribution of *C. compar* was highly aggregated only during the 1994–2000 sampling period and conformed to the negative binomial distribution (Table 1). Over the entire study, total males outnumbered females (♂/♀ = 1.2); this ratio differed from 50:50 ($\chi^2_1 = 28.3$, $P < 0.05$). The ratio of nymphs to females was 2.3.

Columbicola columbae

This was the next most commonly encountered species of chewing louse. Of 322 birds, 169 were infested (52.5%; 95% confidence interval = 46.9–58.1) with a mean intensity of 60.4 (95% confidence interval = 47.4–78.3, range = 1–665). For this species too, the prevalence of infestation was significantly greater among birds sampled in 2003–2006 than during 1994–2000 (Table 1). However, the mean intensity of infestation among washed birds only did not differ significantly between the two sampling periods (Table 1). When the data for all birds ($n = 322$) were analyzed, the observed frequencies of lice did not conform to the negative binomial distribution (variance/mean = 205.4, $D = 0.854$). When the frequency distributions for the two periods, 1994–2000 and 2003–2006, were analyzed, the observed and expected frequencies were different in both cases ($P < 0.05$, D (1994–2000) = 0.89, D (2003–2006) = 0.86). Over the entire sampling period, females slightly outnumbered males (♂/♀ = 0.96), but this ratio did not differ significantly from 50:50 ($\chi^2_1 = 1.0$, $P > 0.05$); the ratio of nymphs to females was 4.8.

Hohorstiella lata

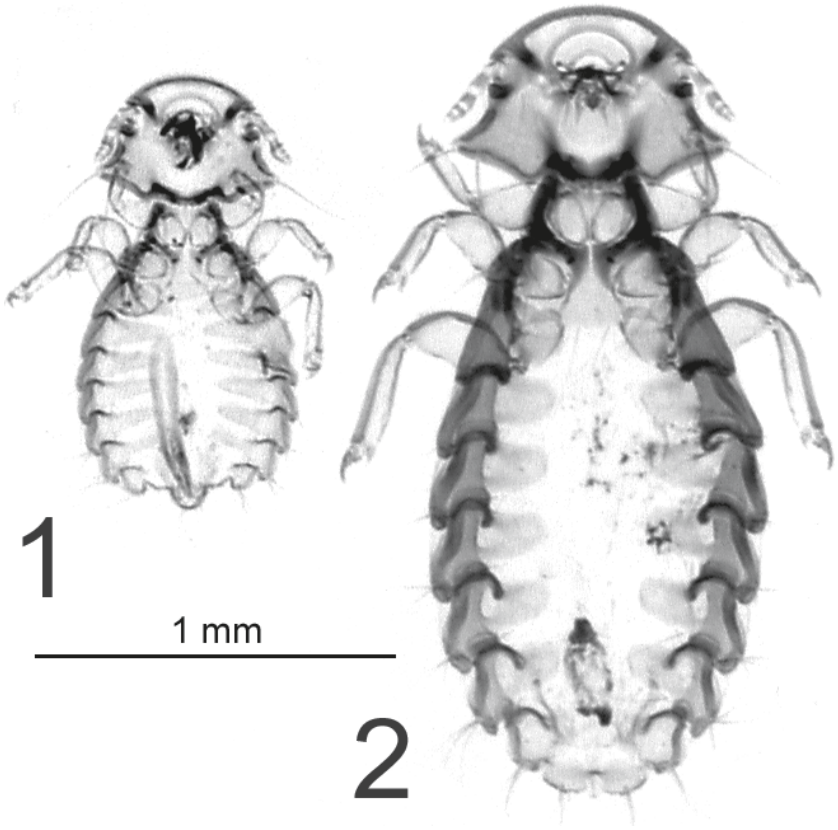
Blood was frequently observed in the gut of this chewing louse. It was found on 75 of the 322 pigeons examined in this study (23.3%; 95% confidence interval = 18.8–28.3) at a mean intensity of 27.8 (95% confidence interval = 5.8–114.8, although these limits are uncertain). However, this species was relatively scarce during 1994–2000, when the prevalence was only 7.0% (95% confidence interval = 3.1–13.4) and the mean intensity of infestation was 3.4 (95% confidence interval = 1.8–6.0). During 2003–2006, the prevalence (32.2%; 95% confidence interval = 25.9–39.0) and mean intensity (30.7; 95% confidence interval = 6.2–121.4, although these limits are uncertain) were greater ($P < 0.05$) than during 1994–2000. The range of infestation during 1994–2000 was quite low (1–10) compared with

Table 1. Infestation parameters for chewing lice found on rock pigeons, *Columba livia* Gmelin, in Manitoba.

	1994–2000 ($n = 114$)					2003–2006 ($n = 208$)				
	Prevalence (%)	Mean intensity*	k	D	Variance/ mean ratio	Prevalence (%)	Mean intensity	k	D	Variance/ mean ratio
Campanulotes compar	56.1† (46.5–65.4)	28.7‡ (18.5–44.5)	0.194	0.80	78.9	91.8† (87.2–95.2)	55.2‡ (44.6–70.0)	—	0.66	148.7
Columbicola columbae	26.3† (18.5–35.4)	54.2 (30.3–85.2)	—	0.89	102.4	66.8† (60.0–73.2)	62.2 (45.8–83.6)	—	0.83	217.8
Hohorstiella lata	7.0† (3.1–13.4)	3.6 (1.6–6.3)	0.04	0.95	5.9	32.2† (25.9–39.0)	30.7 (5.9–126.9)	—	0.96	1283.1
Coloceras tovornikae	—	—	—	—	—	39.9 (33.2–46.9)	8.5 (6.4–11.5)	0.16	0.84	21.4

Note: Numbers in parentheses show ±95% CI.
*Mean intensities for washed birds only ($n = 84$), 1995–2000.
†Prevalences differ significantly ($P < 0.05$) within rows.
‡Mean intensities differ significantly ($P < 0.05$) within rows.

Figs. 1, 2. *Coloceras tovornikae*: 1, male; 2, female.



that in 2003–2006, when the range was 1–59, in addition to 1 bird from Winnipeg examined in October 2003, which harboured 1611 *H. lata* (199 males, 656 females, and 756 nymphs). Overall, females considerably outnumbered males (♂/♀ = 0.30), and this ratio differed significantly from 50:50 (χ^2_1 = 32.19, $P <$ 0.05), although the total numbers of males and females were small. There were, on average, 1.25 nymphs per female. Of species infesting pigeons, this is the one whose prevalence and intensity increased most dramatically from 1994–2000 to 2003–2006 (Table 1). This is the first published record of *H. lata* in Canada.

Coloceras tovornikae Tendeiro
(Figs. 1, 2 and 3–5)

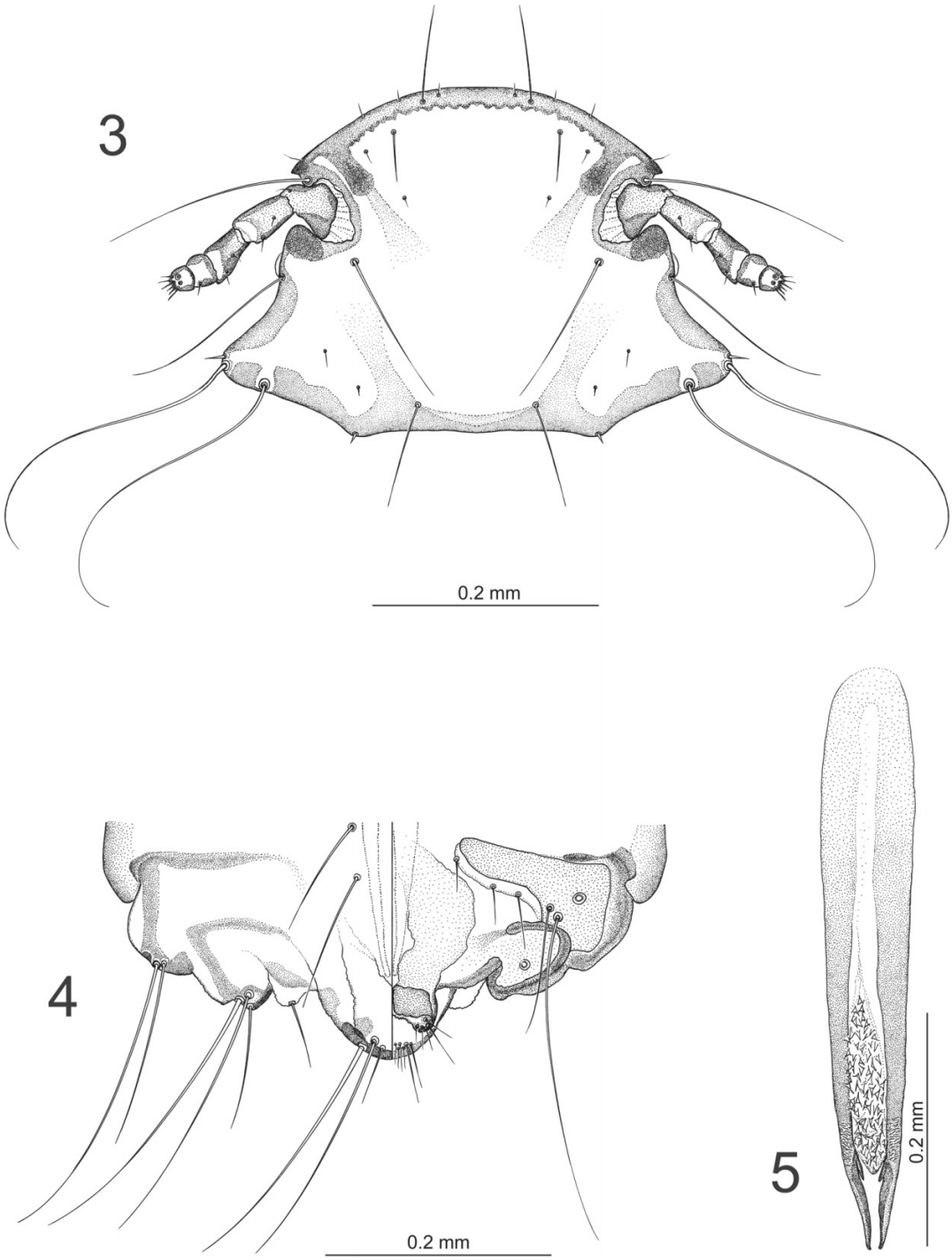
Tendeiro (1973: p. 440) based his description of *C. tovornikae* on one female collected from *Columba livia livia* Gmelin in Metkovic, Croatia, in 1963. All the *Coloceras* females collected in Manitoba agree in their anatomical features with those given and illustrated by Tendeiro (1973: Figs. 67–68 and photographs 159–161) for the holotype. In particular, our females have the characteristic head of *C. tovornikae*, with a very short preantennal region as well as the same terminalia and abdominal plates plus buttresses.

As the male of *C. tovornikae* has not been described or reported in the literature, we present here the first description and illustrations based on the many specimens collected during this study.

Male as in Figure 1. Total length 1.26–1.42 mm. Head as in Figure 3; length 0.36–0.39 mm, width 0.53–0.56 mm; cephalic index 1.45. Preantennal region characteristically short. Ocular and occipital setae long, both much longer than in female. Antennae with 3rd segment slightly enlarged at its distal end, 4th and 5th segments slightly compressed. Terminalia as in Figure 4. Genitalia as in Figure 5.

The first collection of *C. tovornikae* on a Winnipeg rock pigeon that died on 23 March 2003 was a complete surprise because none had been collected from the 114 pigeons examined

Figs. 3–5. *Coloceras tovornikae*: 3, male head, dorsal view; 4, male terminalia, dorsal and ventral views; 5, male genitalia.



during 1994–2000. Birds infested with this louse were encountered with relative frequency thereafter (range = 1–62, n = 208, prevalence = 39.9%, 95% confidence interval = 33.2–46.9, mean intensity = 8.5, 95% confidence interval = 6.4–11.5). The distribution of *C. tovornikae* was highly aggregated and fit the negative binomial distribution (k = 0.16, D = 0.84, variance/mean ratio = 21.4). Females significantly outnumbered males (♂/♀ = 0.74, $\chi^2_1 = 7.01$, $P \leq 0.05$); the ratio of nymphs to females was 2.3. Infested birds came mostly from Winnipeg (n = 72), but there were 4 infested birds from Glenlea and 1 from Portage la Prairie; 6 infested birds were from undetermined localities in Manitoba. We believe that these are the first published specimen-based records of the genus *Coloceras* and of *C. tovornikae* on *C. livia* in North America. Emerson (1972) included *Coloceras damicorne* (Nitzsch) in his list of species found in North America, but Hill and Tuff (1978, p. 323) and Johnson and Clayton (2003, p. 462) maintained that there were no records of *Coloceras* spp. on rock pigeons or other columbiforms in North America.

Stragglers and contaminants

Straggling and contamination are insidious problems in a study like this because most birds are obtained from a wildlife rehabilitation facility where large numbers of diverse species of birds are processed each day. Species of lice that typically infest *C. livia* were found on other species of birds in Manitoba, some of which are non-predatory. The records from the non-predatory species are not reported here, as they are almost certainly the result of contamination (although it is not known whether this occurred before or after the birds were submitted to the Manitoba Wildlife Rehabilitation Organization). However, the following specimens were found on raptors, many of which are expected to prey or scavenge on pigeons. Although there is a small chance that some of these records might be contaminants, they are probably genuine examples of straggling to the predatory species, especially since raptors do not come into close contact with other species at the hospital facility.

Columbicola columbae — Cooper's hawk, *Accipiter cooperii* (Bonaparte), Sarto, 3.x.1996, 1♀; great horned owl, *Bubo virginianus* (Gmelin), Stonewall, 9.xi.2002, 1♀; great horned owl, Winnipeg, 14.i.2002, 1♀. *Columbicola* sp.: merlin, *Falco columbarius* L., Altona, 24.vii.2004, 1n; eastern screech-owl, *Otus asio* (L.), Winnipeg, —.ix.1995, 1n.

Campanulotes compar — Cooper's hawk, Steinbach, 11.x.2000, 1♂, 2*n*; peregrine falcon, *Falco peregrinus* Tunstall, Winnipeg, 23.vii.1997, 1♂; merlin, Winnipeg, 5.viii.2005, 1♀; great horned owl, Winnipeg, 14.i.2002 (same bird as above), 1♀; great horned owl, Portage la Prairie, 19.ii.2004, 3♀; great horned owl, Dugald, 10.vi.2004, 1♀; snowy owl, *Nyctea scandiaca* (L.), Portage la Prairie, 22.iii.1997, 1♂; eastern screech-owl, Winnipeg, —.x.1995 (same bird as above), 1♂.

Coloceras tovornikae — short-eared owl, *Asio flammeus* (Pontoppidan), Lorette, 29.viii.2006, 1♀.

Zenaida macroura

A total of 117 mourning doves were examined during this study and, as was the case for rock pigeons, most came from Winnipeg (73.5%, n = 86). Other birds came from the following localities in Manitoba: Glenlea (n = 3), Anola and Niverville (n = 2 each), and Altona, East Selkirk, Emerson, Grosse Isle, Headingley, La Salle, Lockport, Portage la Prairie, Sandy Hook, and St. Paul (n = 1 each). There were 14 birds for which no specific localities were available, all salvaged in 1997. The following numbers of birds were examined in successive years of the survey: 6 in 1994, 21 in 1995, 13 in 1996, 21 in 1997, 2 in 1998, 20 in 1999, 3 in 2000, 9 in 2001; 3 in 2002, 10 in 2003, 5 in 2004, 1 in 2005, and 3 in 2006. Most birds were sampled during the months of the migration and the breeding season, May to October (n = 110), but a small number were examined during November to April (n = 7).

A total of 1260 lice of six species were found on mourning doves: *B. columbae*, *H. paladinella*, *Columbicola macrourae* (Wilson), *C. baculoides*, *Physconelloides zenaidurae* (McGregor) (Philopteridae), and one male *C. tovornikae*. Over the entire study, 63 of the 117 birds (53.8%) were infested with at least one louse, and the mean intensity of infestation was 19.98 (95% confidence interval = 14.6–27.0, range = 1–99). One bird was examined in each of the five months outside the season of expected occurrence for mourning doves in Manitoba: January, February, March, November, and December. Only one of those birds (from December) was infested with lice, in this case with *P. zenaidurae*. Among the infested birds, 28 (44.4%) were infested with only one species of louse (3 with nymphs only of *Columbicola* sp.), 27 (42.9%) were infested with two species of lice, 6 (10.0%) were infested with

three species, and 2 (3.3%) were infested with four species.

Physconelloides zenaidurae

This was the species most commonly found on mourning doves in this study: 496 lice, or 39.4% of the total collected. The prevalence of infestation by this species was 29.1% (95% confidence interval = 21.0–38.2) and the mean intensity was 12.0 (95% confidence interval = 7.4–19.9); the maximum number found on one bird was 77. The distribution of *P. zenaidurae* fit the negative binomial distribution (k = 0.095, D = 0.887, variance/mean ratio = 34.8). Females slightly outnumbered males (♂/♀= 0.82), but the ratio was not significantly different from 50:50 (χ^2_1 = 0.98, $P > 0.05$); the ratio of nymphs to females was 2.9. This is the first published record of *P. zenaidurae* in Canada, collected from 25 birds found in Winnipeg and from 1 bird each from Lockport, Altona, Glenlea, Sandy Hook, and Anola.

Columbicola baculoides and C. macrourae

These were the next most abundant species (*C. baculoides*: n = 300, range = 1–53; *C. macrourae*: n = 262, range = 1–84), the prevalence of infestation for each being 27.4% (95% confidence interval = 19.5–36.4) and 18.8% (95% confidence interval = 12.2–27.1) and the mean intensity of infestation 9.4 (95% confidence interval = 6.4–14.3) and 11.9 (95% confidence interval = 6.5–25.9), respectively. Distributions for both species were highly aggregated: for *C. baculoides*, k = 0.098, D = 0.872, variance/mean ratio = 20.9, and for *C. macrourae*, k = 0.056, D = 0.929, variance/mean ratio = 40.4. These are the first published records of *C. baculoides* in Manitoba (21 from Winnipeg, 1 from Altona, 1 from East Selkirk, 1 from Headingley, 1 from Niverville, 6 from unknown locations) and the first of *C. macrourae* (18 from Winnipeg, 1 from Lockport, 3 from unknown locations) in Canada. Nine birds were infested with adults of both *C. baculoides* and *C. macrourae* and with 2, 7, 11, 14, 17, 17, 20, 22, and 31 nymphs. Eight birds were infested with nymphs of *Columbicola* spp. (five with 1 nymph, two with 2 nymphs, one with 4 nymphs) but with no adults of either species. No attempt was made to differentiate the nymphs of these two species, so actual prevalences and mean intensities for both *Columbicola* spp. are slightly higher than those presented above. There were equal numbers of males and females of *C. macrourae*; the ♂/♀ ratio for *C. baculoides* was 0.58, although their numbers were too small for valid statistical comparison.

Hohorstiella paladinella

The prevalence of infestation by *H. paladinella* was 3.4% (n = 4, range = 1–19, 95% confidence interval = 0.93–8.5) and the mean intensity was 9.5 (95% confidence interval = 2.3–15.8). Distribution of this species was highly aggregated (k = 0.01, D = 0.97, variance/mean = 14.1). Only 38 specimens of this species were collected, the ♂/♀ ratio being 0.2, but again there were too few adults for valid statistical comparison. The ratio of nymphs to females was 2.6. This is the first published record of *H. paladinella* in Canada; it was found on birds from Winnipeg (n = 3) and Anola (n = 1).

Bonomiella columbae

Among the chewing lice typically parasitic on mourning doves, this species was collected in the smallest numbers, only nine specimens, four of which were males, four females, and one nymph. Four birds were infested (3.4%, range = 1–3, 95% confidence interval = 0.93–8.5) at a mean intensity of 2.3. These are the first published records for *B. columbae* in Manitoba, one bird each from Winnipeg and Niverville and two from unknown locations in the province.

The record of one male *C. tovornikae* from a bird found in Winnipeg in 2004 is probably a straggler, or perhaps even a contaminant from an infested rock pigeon.

None of the species of chewing lice from mourning doves were found on any other bird species in the survey.

Discussion

It is clear from this study that prolonged sampling of a relatively intensive nature can result in a considerable increase in our understanding of chewing lice on even the most common bird hosts. Besides the first records of several species of lice for Manitoba and Canada included in this study, the most surprising finding was *C. tovornikae* on *C. livia* in Manitoba. As far as we know, this species is known from only one specimen, the holotype female, collected in Metkovic, Croatia, in 1963 (Tendeiro 1973). Here we have an example of an introduced species of ectoparasite becoming established on a previously introduced host with its

own resident community of exotic ectoparasites. Its occurrence in Manitoba is probably the result of human intervention, but how this infestation may have arisen is speculative, and we cannot say when or where it was introduced into North America. There have been no intensive studies of lice on pigeons in Canada, and this species was not collected on 114 rock pigeons examined in this study during 1994–2000. It is possible that it was accidentally introduced along with pigeons brought in under permit or illegally into North America from Eastern Europe and was present at undetectable levels in Manitoba until 2003. This species was known from only one specimen prior to this study, so although we know that it is rare in collections, we really know nothing about its prevalence and intensity of infestation on pigeons in the Palaearctic region. The chances of its introduction into North America seem remarkably small, but its relative abundance in Manitoba now is evidence that it is firmly established. It is regrettable that sampling for lice on pigeons was conducted less intensively after 1997 and then discontinued after 2000; it was by chance that sampling was resumed in 2003. Thus, we cannot say with greater precision when *C. tovornikae* might otherwise have been first encountered. Given that *C. tovornikae* has not yet been reported elsewhere in North America, it seems prudent to initiate surveys of lice on *C. livia* at widely distributed locations, especially in eastern North America, to see where else it may be found. If this species has been recently introduced, it may still be possible to plot its further pattern and rate of dispersal, and perhaps even gain insight into its port of entry and potential interaction with previously introduced ectoparasites on rock pigeons.

It is difficult to compare infestation parameters in our study with those of studies conducted elsewhere in the world, especially in view of the widely different sampling methods used. For example, Rózsa (1990) found 92% and 77% of feral pigeons in Hungary to be infested with *C. columbae* and *C. compar* at intensities of 17.9 and 5.4, respectively. In Santiago, Chile, the prevalence of infestation with *C. columbae* and *C. compar* was 59% and 26% of pigeons, respectively (Toro *et al.* 1999), and 53% of pigeons in Uberlándia, Brazil, were infested with *C. columbae* (Oliveira *et al.* 2000). In those studies, lice were collected manually during visual inspection of sampled birds. Results in our study were affected slightly by a change in sampling methods. The prevalence of infestation increased significantly during 2003–2006 for three of the four species of lice found in pigeons, as did the intensity of infestation for *C. compar* (Table 1). Part of these differences could be attributed to changing from ruffling through the feathers of dead birds and collecting fallen lice from the surface of a white enamel pan to the more efficient technique (Clayton and Drown 2001) of washing birds. This difference could most certainly account for differences in intensity of infestation or for low prevalence and intensity (*e.g.*, for *H. lata*), so mean intensities of infestation were compared on washed birds only. Because intensities of infestation for *C. compar* and *C. columbae* were relatively high, there is less likelihood that an infestation was missed by ruffling. Therefore differences in prevalence for these species between the sampling periods are more likely to be valid. The question here concerns the extent to which increased infestations may be attributable to the presence of birds with paramyxovirus infection. Factors that affect a pigeon's ability to groom effectively may ultimately result in greater infestation with chewing lice (Clayton 1991). The degree to which virus infection secondarily affects ectoparasite load has not been demonstrated.

We have added considerably to our knowledge of the chewing louse fauna parasitizing Columbiformes in Manitoba, as well as Canada and North America. In addition to the new record of the genus *Coloceras* and the species *C. tovornikae* for North America, there were no previous published records of *B. columbae*, *C. compar*, *C. baculoides*, *C. columbae*, *C. macrourae*, *H. lata*, *H. paladinella*, or *P. zenaidurae* for Manitoba, and no records of four of these species for Canada. Although *B. columbae* has been reported on domestic pigeons from British Columbia (Emerson 1957*b*), it was not found on the 322 specimens of this host examined during our survey in Manitoba. Instead, we found it at a relatively low incidence on mourning doves, a new host record for Canada, although it has been reported from this host in the United States of America (Conti and Forrester 1981). Furthermore, no specimens of *B. columbae*, *C. baculoides*, or *H. paladinella* were reported in a survey of parasites of mourning doves in Illinois (Hanson *et al.* 1957). The sample in this survey was larger than ours but apparently the birds were not examined as rigorously for ectoparasites. Further survey work should help

determine whether these anomalies are related to sampling effort or indicate real disparities in distribution.

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