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UTILIZATION OF ANIMALS FROM CANADIAN WILDLIFE REHABILITATION HOSPITALS TO STUDY THE TAXONOMY AND ECOLOGY OF PARASITIC LICE (PHTHIRAPTERA) AND OTHER ECTOPARASITES

Uso de animales tratados en centros canadienses de rehabilitación de fauna silvestre para estudiar la taxonomía y ecología de piojos parásitos (Phthiraptera) y otros ectoparásitos

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ABSTRACT. – I aim to examine the advantages and disadvantages of sourcing wildlife from Canadian rehabilitation hospitals to study ectoparasite ecology and parasitology. A survey conducted in Manitoba, Canada, has relied heavily on salvaged wildlife (> 12 400 hosts) through collaboration with wildlife hospitals from 1993 to 2023. The advantages of this approach included access to a considerable bird and mammal diversity (296 species). Sample sizes for many species were large, and individuals came from a wide geographic area. I salvaged animals euthanized because of casualties or which died in care. Thus, I did not have to sacrifice animals for rigorous ectoparasite sampling. Because animals became available opportunistically, it was only possible for me to sample small numbers (n ≤ 10) of many species, and I had no control over where or when samples arose. It is necessary to consider biases from juvenile animals and, in some cases, from animals sick or injured for an unknown time. Although most hosts had comprehensive data on provenance, persons occasionally submitted animals with missing data. Hospital staff always exercised care to avoid cross-contamination of ectoparasites where many species arrived and avoid potentially infectious pathogens. In conclusion, wildlife rehabilitation hospitals are a valuable resource for ectoparasite research.
KEY WORDS: biodiversity, ecology, host-parasite interactions, parasitology.

RESUMEN. – Examino las ventajas y desventajas de usar animales procedentes de hospitales canadienses de rehabilitación para estudiar la ecología y parasitología de ectoparásitos. Un estudio en Manitoba, Canadá, incluyó animales recuperados entre 1993 y 2023 mediante la colaboración con hospitales de rehabilitación (> 12 400 hospedadores). Gracias a esto accedí a una considerable diversidad de aves y mamíferos (296 especies). La muestra de muchas especies era grande y los individuos procedían de una amplia zona geográfica. Ya que recuperé animales eutanizados o que murieron en cuidados médicos, no debí sacrificar animales para muestrear rigurosamente ectoparásitos. Dado que la disponibilidad de animales fue variable, solo pude muestrear pequeños números (n ≤ 10) de muchas especies, y no tuve control sobre dónde o cuándo surgieron las muestras. Hay que considerar el sesgo causado por los animales jóvenes y los que estuvieron enfermos o heridos un tiempo desconocido. Aunque la mayoría de los hospedadores tuvieron datos completos de su procedencia, hubo algunos con datos incompletos. El personal del hospital tuvo cuidados para evitar la contaminación cruzada de ectoparásitos y el contagio con patógenos infecciosos cuando había muchas especies. En conclusión, los hospitales de rehabilitación de fauna silvestre son un recurso valioso para estudiar ectoparásitos.
PALABRAS CLAVES: biodiversidad, ecología, interacciones huésped-parásito, parasitología.

INTRODUCTION

As Miriam Rothschild pointed out in the Foreword, Adrian Marshall's book (1981) opened up, "…a fascinating world for a new generation of biologists." Since that time, there have been increasing numbers of entomologists increasingly engaged in the exploration of ectoparasites and their relationships with their hosts. There is little doubt that parasitic lice (Phthiraptera) make up the majority of species among ectoparasitic insects. In fact, there are genera of chewing lice that still hold a vast, undescribed diversity of species (*e.g*., Valim & Weckstein 2013, Bush *et al*. 2016, Gustafsson & Bush 2017). Daniel González-Acuña was one such biologist who strived to expand our knowledge of these ectoparasites. It is with respect for his interests that I acknowledge his many contributions to ectoparasite ecology and taxonomy and submit the following account.

In the late 1980s, I was a member of the Scientific Committee of the Biological Survey of Canada (https://biologicalsurvey.ca/). The objectives of one project in which I was involved were to survey the status of our knowledge of the ectoparasites of vertebrates in Canada and make recommendations going forward (Galloway & Danks 1991). Striking among the findings was that, in general, information about ectoparasites was seriously deficient. In fact, specialists have recorded only ≈ 50% of the described species of parasitic lice and only ≈ 2% of parasitic astigmatid mites expected to infest known hosts in Canada. Specialists have recommended that these groups should be targeted, and that entomologists should adopt an integrated approach involving ornithologists and mammalogists.

In 1993, the Manitoba Wildlife Rehabilitation Organization (MWRO, now Wildlife Haven Rehabilitation Centre, Île des Chênes) moved into their new facilities at the Glenlea Research Farm of the Faculty of Agricultural and Food Sciences at the University of Manitoba. On my first visit with the MWRO hospital director, Brian Ratcliff, we arranged opportunities for me to collect ectoparasites from wildlife presented at their rehabilitation hospital. Over time, I was given wildlife individuals that either succumbed following submission or had been euthanized because of the seriousness of their condition on arrival. Since that time, I have examined more than 12 465 individuals, including birds and mammals. Most samples were from the MWRO, the Prairie Wildlife Rehabilitation Centre (PWRC, St. Adolphe), and other sources in Manitoba. From these experiences, my objective in this paper is to describe the advantages and disadvantages associated with sourcing wildlife from rehabilitation hospitals for the study of ecology and taxonomy of ectoparasites. However, I somewhat limit presented data to parasitic lice. For a more comprehensive review of various additional methods of collecting ectoparasites see Marshall (1981) and Clayton & Walther (1997).

ADVANTAGES OF SALVAGED ANIMALS FROM WILDLIFE REHABILITATION HOSPITALS

Access to diverse host animals

Wildlife rehabilitation hospitals regularly receive injured and variously affected animals of considerable variety. Once aware of the presence of local hospitals, the public will kindly submit or report almost any species of host. Over 30 years, I have examined 296 host species in Manitoba for ectoparasites, including 248 species of birds and 48 species of mammals. With widespread awareness comes the greater likelihood that uncommon, rarely examined species of hosts or even threatened and endangered species may become available. Examples among these during the current survey are Common Nighthawk (*Chordeiles minor*; n = 235) and Eastern Whip-poor-will (*Antrostomus vociferus*; n = 13) (Galloway 2006, Galloway & Lamb 2015, Kuabara *et al*. 2020), Barn Swallow (*Hirundo rustica*; n = 101), Chimney Swift (*Chaetura pelagica*; n = 8), Least Bittern, (*Ixobrychus exilis*; n = 3), and Golden-winged Warbler (*Vermivora chrysoptera*; n = 1).

Good quality of host animals

To guarantee an accurate assessment of ectoparasite populations, it is crucial to examine the host as soon as possible after acquisition. Because some ectoparasites may leave a host shortly after death, an examination of the live host is preferable. However, there are few options available for collecting methods of ectoparasites at this time. Animals submitted to rehabilitation hospitals are often alive, though in many cases injured, so permanent ectoparasites such as lice and most parasitic mite species remain on the host. Some ectoparasites may abandon the host during triage. Trained hospital staff use care handling their patients, and those animals that require euthanasia or that die in care are immediately bagged individually and frozen by the staff. So, this protocol contributes to minimizing ectoparasites lost. We must keep in mind that the ectoparasite number on subsequent examination represents a minimum population size. This is particularly the case with mobile, temporary ectoparasites such as hippoboscid flies, fleas, and ticks.

Adequate sample sizes

Adequate sample sizes are paramount in discovering species of ectoparasites that infest their hosts at low prevalence and reaching sound conclusions about quantitative aspects of ectoparasite infestation. In the Manitoba survey, 53.4% (n = 158) of the species examined had a sample size of more than ten individuals (Fig. 1). Some of the most common species, such as Eastern Cottontail (*Sylvilagus floridanus*; n = 392), House Sparrow (*Passer domesticus*; n = 457), American Robin (*Turdus migra-*

torius; n = 574), and Rock Pigeon (*Columba livia*; n = 811), were represented in large numbers. This allowed an investigation of population biology of their permanent ectoparasites, such as parasitic lice (Galloway 2012, Galloway *et al*. 2021, Galloway & Lamb 2014, 2015, Lamb & Galloway 2016, 2018, 2019).

Determination of the host's geographic distribution

Animals which ultimately reach rehabilitation hospitals may be most representative of the immediate area of the hospital. For example, 67.3% of all animals examined in Manitoba were from Winnipeg. However, many animals arrive at the hospital from considerable distances. Submitted animals came from more than 300 different locations around the province. Some animals arrived from as far away as Churchill, a transition zone from boreal forest to Arctic tundra more than 1000 km north of Winnipeg. Because of the wide distribution of individuals, species from different ecological zones become available for study, as well as the likelihood of increased host diversity. I must point out that most bird species examined in the Manitoba study are migratory and may only be transient in the location where they were injured. For species nesting in northern tundra or boreal forests, their brief period of occupation in the south of the province during spring and autumn may be the only time when they are likely to be submitted to rehabilitation hospitals.

Estimation of the total ectoparasite population

Once animals die, it is possible to examine them using more invasive methods. Vigorous washing is one of the most efficient means of collecting most ectoparasites (Clayton & Drown 2001). If the objective is to determine the spatial distribution of ectoparasites on the host body, one can remove individual body regions and wash them separately. By this method, one can identify populations of ectoparasites in each body region (Grossi & Galloway 2022). Alternatively, one can remove and dissolve the skin or hide as another means of determining near-total ectoparasite populations (*e.g.*, Choe & Kim 1987). It is also easy to examine birds for nasal mites (*e.g.*, Knee & Galloway 2017, Knee *et al*. 2008), quill mites (*e.g.*, Bochkov & Galloway 2001, 2004), and skin mites (*e.g.*, Harpirhynchidae; Bochkov & Galloway 2004, 2013), species less easily accessed through examination of live hosts.

In either case, one can pass samples through a fine-mesh screen (90 µ in this study) to retain all ectoparasites in a sample (Fig. 2) and preserve them in ethanol. Then, one can sort specimens using a stereomicroscope. Ectoparasites of all sizes and degrees of pigmentation are visible under magnification, countable and removable from the sample. Early instars and teneral individuals of parasitic lice are often small and weakly pigmented (*e.g.*, *Anatoecus* and *Goniocotes*). One can sort specimens using a white or black background to enhance contrast and facilitate sorting efficiency.

No animals are sacrificed

Ethical considerations often preclude random collection of most species of wildlife. Exceptions include exotic, in-

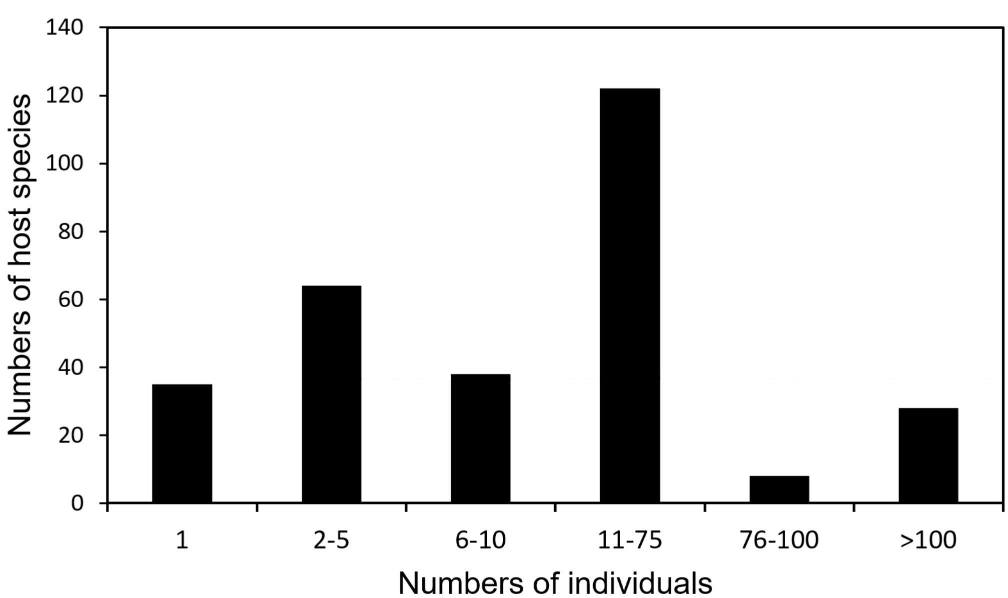

Figure 1. Distribution of 296 species of hosts (birds = 248; mammals = 48) according to numbers of individuals of each species examined for ectoparasites in Manitoba, Canada, 1993-2021.

Figure 2. Sample washed from a Pileated Woodpecker (*Dryocopus pileatus*) onto a 90 μ brass sieve. The sample is rinsed into a bottle, upper left, and preserved with 95% ethanol for later sorting and removal of ectoparasites (Photo by Jordan Bannerman).

troduced species, game and fur-bearing animals, and nuisance species. In general, native wild species come under some level of protection and regulation from government agencies. Wildlife hospitals are regulated under protocols set by federal and provincial guidelines in Canada and may be allowed to admit virtually all species to their facilities. Animals euthanized or that died naturally can then be examined for ectoparasites, though still under the authority of regulatory agencies, which require permits and proper reporting and disposal. The primary benefits come from the ability to evaluate a wide variety of wild species without the necessity to kill wild animals and negatively affect their populations. A bonus is that the hosts can be deposited in museum collections as vouchers after being examined for ectoparasites.

DISADVANTAGES OF SALVAGED SPECIMENS FROM WILDLIFE REHABILITATION HOSPITALS

Sample size limitations

While 53.4% of species examined in this study had a sample size of more than ten specimens each, a considerable number of species had a sample size of ≤ 10 specimens (n = 138 species; Fig. 1). Of these, 34 species were represented by only one specimen, from 13 of which no ectoparasites were collected: Parasitic Jaeger (*Stercorarius parasiticus*), Baird's Sandpiper (*Calidris bairdii*), Semipalmated Sandpiper (*Calidris pusilla*), Spotted Sandpiper (*Actitis macularius*), Barn Owl (*Tyto alba*), Bobolink (*Dolichonyx oryzivorus*), Golden-winged Warbler, Northern Mockingbird (*Mimus polyglottos*), Orchard Oriole (*Icterus spurius*), Scarlet Tanager (*Piranga olivacea*), Veery (*Catharus fuscescens*), Yellow-throated Warbler (*Setophaga dominica*), and Pygmy Shrew (*Sorex hoyi*).

Small sample sizes may occur because host species are less common, vagrant, or occur less frequently where people are likely to encounter injured individuals. Even when small numbers of a host species are available for examination, there is the opportunity to collect undocumented ectoparasites and contribute to knowledge of local faunal diversity. However, robust assessment of infestation parameters and patterns of seasonal infestation requires larger sample sizes. Where species of ectoparasites have low prevalence, their presence may go undetected in the region unless larger sample sizes are attainable. In collaboration with rehabilitation hospitals, where the availability of various species of hosts is unpredictable, patience and persistence are required, perhaps over many years.

Uncertainty of the geographic origin and temporal distribution of samples

For specific ecological studies, it is often preferable that samples come from a clearly defined location within a clearly defined timeline. However, this is not possible because of the opportunistic nature of hosts from rehabilitation hospitals. As described above, 33.7% of hosts examined in this study came from more than 300 widely scattered locations other than Winnipeg and mostly near small towns. Because many species of birds in Manitoba are migratory, they are available for study only during relatively short seasons as they travel into and out of the province or to more northern breeding locations. Consequently, it may take several years to accumulate enough data from a sufficiently large sample of hosts to allow for suitable analysis. That was the case for several studies on Common Nighthawk (Galloway 2006, Galloway & Lamb 2015), owls (Galloway & Lamb 2019, Lamb & Galloway 2019), Bald Eagle (*Haliaeetus leucocephalus*; Lavallée *et al*. 2020), and thrushes (Galloway *et al*. 2021).

Biases in the infestation intensity

Although some animals submitted to wildlife rehabilitation facilities are healthy and fit, such as the case of young animals abandoned by parents, the majority are in some way incapacitated. Incapacitation may result from traumatic injury (*e.g.*, window strike, cat mauling, vehicle collision), starvation, sickness, poisoning, or hypothermia. In addition, larger animals are often emaciated and dehydrated. The length of time from when a host could no longer care and groom for itself, and thus where there may be an impact on its populations of ectoparasites, is rarely known or recorded. Such bias is unlikely to alter the prevalence of infestation significantly since hosts will have maintained the infestation at the time of their incapacitation. However, the impact on infestation intensity warrants greater concern, especially if the host has been incapacitated for a lengthy period, sufficient time for ectoparasites to have passed through one or more reproductive cycles. Hosts with severe traumatic injuries are unlikely to survive long in the wild, and such animals are not suitable for release into the wild. These animals are usually euthanized shortly after assessment during triage.

Occasionally, animals with particular deformities may support an unusually high infestation intensity. For example, a juvenile Double-crested Cormorant (*Phalacrocorax auritus*) with a deformed beak under an emaciated condition near Lac du Bonnet, Manitoba, had an infestation of 1228 adult *Pectinopygus farallonii*. This unusually high infestation level could partially be attributable to the deformed bill as it would have diminished the cormorant's ability to preen and obtain food.

Younger animals tend to predominate in submissions to rehabilitation hospitals for most host species (*e.g*., Galloway 2012, Grossi 2013). These are typically young-of-the-year animals with little experience on their own, which are particularly vulnerable to attack by predators and accidents. The extent to which this may affect the prevalence and intensity of infestation is demanding to establish quantitatively. That requires knowing infestation parameters in parents and siblings, the host's age, or the efficiency of grooming in each host species. Nonetheless, this creates a factor of bias in a study.

Deficiencies in collection data

Precise locality data are always preferable for collections of any organisms. Unfortunately, this is not always the case for hosts submitted to rehabilitation hospitals. Sometimes, people even leave animals on the doorstep after hours when there are no staff to record pertinent information. Occasionally, submitted hosts come from a veterinary clinic or a friend of the person(s) who found the injured animal. Sometimes, the person who found the animal may have kept it under less-than-ideal conditions. Although most rehabilitation hospitals have standardized submission forms soliciting critical information, important data may not always be available.

Cross-contamination

Wildlife rehabilitation hospitals may take in considerable numbers of different species in a year and even over a day. At certain times of the year (*e.g*., during migration), a hospital may receive many animals that require immediate care. As a result, at peak periods, staff may be faced with examining and treating a considerable number of animals in a short period. During these periods, there is a greater risk of cross-contamination. This can follow repeated use of a towel or blanket or ectoparasites falling from a host onto a surface where they may later transfer to a different host. This is an insidious risk a researcher must always consider as a possibility, especially where an atypical ectoparasite species appears on a host.

A species of louse found on an unlikely host (*e.g*., a pelican louse on a passerine bird) is almost certainly an accidental contaminant. However, cross-contamination may not be so apparent when an ectoparasite is an undescribed species of a genus associated with a possible host (*e.g*., an undescribed species of *Brueelia* on a passerine). Predators often become infested with ectoparasites from their prey. However, in a wildlife hospital setting, it may not be definitively possible to determine whether this was a natural transfer from prey to predator or a case of contamination in the hospital facility. It may be possible over time to confirm host-parasite associations by repeated collections from that same host species. However, this may not always be possible. The best defense is for staff to be well-trained and well-informed about the possibility of cross-contamination and incorporate best practices to minimize the risk of occurrence.

Exposure to pathogens

As is the case whenever handling wildlife, there is a risk of exposure to potential pathogens. In Manitoba, where staff have examined > 12 000 animals, strict laboratory protocols are in place to minimize exposure. Protective clothing, gloves, and face shield are standard practice when processing animals. However, an outbreak of Highly Pathogenic Avian Influenza occurred in many parts of North America. Rehabilitation hospitals in Manitoba introduced preventative protocols to minimize the chances of infection entering and spreading within their facilities. Birds could no longer be transferable to other laboratory facilities. Although there is a low risk the Avian Influenza virus infecting humans, no avian species were admitted to laboratory facilities for examination for ectoparasites at the University of Manitoba during the outbreak.

CONCLUSIONS

Since Marshall (1981), there has been tremendous progress in the taxonomy, systematics, and ecology of ectoparasites. Yet there is an ample gap in our knowledge of regional diversity and population dynamics, especially among parasitic lice (Galloway & Lamb 2021). Wildlife rehabilitation hospitals can offer an opportunity for parasitologists to address this gap.

Human activities increasingly affect wildlife in close contact, often with catastrophic impacts on host animals. Animals suffer injuries in collisions with human-built structures, including windows in buildings, wires, lights, and towers. Wild animals can suffer mutilations by bites of domestic cats and dogs. Accidental poisoning and oil spills in terrestrial and aquatic systems are a risk to the well-being of many species. Many host animals suffer injuries or die because of collisions with vehicles. In response to these impacts on wildlife populations and with increasing response to the need for wildlife conservation, rehabilitation hospitals are becoming increasingly abundant in many countries around the world. There are nearly 100 such facilities across Canada designed to care for sick and injured wildlife. Some facilities accept all species, native and introduced (*e.g.*, Wildlife Haven Rehabilitation Hospital, Îles des Chênes, Manitoba), while others specialize in certain species groups (*e.g.*, Canadian Raptor Conservancy, Vittoria, Ontario).

Wildlife rehabilitation hospitals may accept a wide diversity of species (see above), sometimes in considerable numbers. The Wildlife Haven Rehabilitation Hospital in Manitoba received more than 3000 animals to their services in 2021. Respectful and considerate collaboration with personnel at wildlife rehabilitation facilities offers parasitologists opportunities to access species hard to obtain by other means. The number of parasitologists taking advantage of these opportunities seems to be increasing (Appendix 1), with beneficial results for our knowledge of these species.

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Appendix 1. Selected references in chronological sequence to studies on parasitic lice (Phthiraptera) where bird and mammal hosts were obtained through wildlife rehabilitation hospitals.

Taxon	No. of individuals	Location	Reference
Accipitriformes	Not indicated	Spain	Pérez-Jiménez *et al.* (1988)
Accipitriformes Falconiformes Strigiformes	55	Hungary	Solt (1998)
Passeriformes	64	Manitoba, Canada	Galloway (1999)
Accipitriformes Falconiformes Strigiformes	35	California, U.S.A.	Morishita *et al.* (2001)
Accipitriformes Anseriformes Charadriiformes Columbiformes Galliformes Passeriformes Pelecaniformes Piciformes Procellariiformes Suliformes	Not indicated	Florida, U.S.A.	Holt (2002)
Accipitriformes Apodiformes Charadriiformes Ciconiiformes Columbiformes Galliformes Passeriformes Pelecaniformes Procellariiformes Strigiformes Suliformes	Not indicated	Florida, U.S.A.	Holt (2003)
Gruiformes	35	Manitoba, Canada	Galloway (2004)
Accipitriformes Charadriiformes Ciconiiformes Pelecaniformes Strigiformes	Not indicated	Florida, U.S.A.	Holt (2005)
Caprimulgiformes	103	Manitoba, Canada	Galloway (2006)
Columbiformes	322	Manitoba, Canada	Galloway & Palma (2008)
Accipitriformes Falconiformes	Not specified	Chile	González-Acuña *et al.* (2008)
Accipitriformes Anseriformes Ciconiiformes Falconiformes Gruiformes Passeriformes Pelecaniformes Strigiformes	24	Hungary	Rékási (2008)
Carnivora	35	Netherlands	Morick *et al.* (2009)
Pelecaniformes Suliformes	83	Manitoba, Canada	Galloway (2011)
Lagomorpha	285	Manitoba, Canada	Galloway (2012)
Anseriformes	590	Manitoba, Canada	Grossi (2013)
Columbiformes	659	Manitoba, Canada	Galloway & Lamb (2014)

Podicipediformes Suliformes Pelecaniformes Anseriformes Accipitriformes Falconiformes Galliformes Gruiformes Charadriiformes Columbiformes Cuculiformes Strigiformes Caprimulgiformes Apodiformes Coraciiformes Piciformes Passeriformes	Not specified	Manitoba, Saskatch-ewan and Alberta, Canada	Galloway *et al*. (2014)
Anseriformes	757	Manitoba, Canada	Grossi *et al*. (2014)
Passeriformes	192	Manitoba, Canada	McNally (2014)
Caprimulgiformes	178	Manitoba, Canada	Galloway & Lamb (2015a)
Columbiformes	553	Manitoba, Canada	Galloway & Lamb (2015b)
Gruiformes	45	Manitoba, Canada	Galloway (2016)
Piciformes	547	Manitoba, Canada	Galloway & Lamb (2016)
Piciformes	596	Manitoba, Canada	Lamb & Galloway (2016)
Accipitriformes Anseriformes Bucerotiformes Charadriiformes Gruiformes Passeriformes Pelecaniformes Phoenicopteriformes Strigiformes Suliformes	Not specified	Portugal	Tomás *et al*. (2016)
Piciformes	491	Manitoba, Canada	Galloway & Lamb (2017)
Carnivora	1	Turkey	Taşçi *et al*. (2017)
Accipitriformes Bucerotiformes Cuculiformes	Not indicated	Turkey	Dik & Kandir (2018)
Piciformes	478	Manitoba, Canada	Lamb & Galloway (2018)
Strigiformes	697	Manitoba, Canada	Galloway & Lamb (2019)
Strigiformes	508	Manitoba, Canada	Lamb & Galloway (2019)
Accipitriformes	147	Manitoba, Canada	Lavallée *et al*. 2020
Suliformes	15	Brazil	Antonello *et al*. (2020)
Perissodactyla	1	Turkey	Dik *et al*. (2020)
Caprimulgiformes	Not indicated	Manitoba, Canada	Kuabara *et al* (2020)
Accipitriformes	1	Bolivia	Mollericona *et al*. (2020)
Columbiformes	162[a]	Canada	Grossi & Proctor (2020)
Sphenisciformes	171	South Africa	Snyman *et al*. (2020)

Accipitriformes Bucerotiformes Ciconiiformes Columbiformes Coraciiformes Cuculiformes Falconiformes Pelecaniformes Phoenicopteriformes Strigiformes	79	Turkey	Dik & Kandir (2021)
Coraciiformes	51	Manitoba, Canada	Galloway (2021)
Passeriformes	774	Manitoba, Canada	Galloway *et al* (2021)
Accipitriformes Falconiformes Strigiformes	75	Italy	Gherardi *et al*. (2021)
Pelecaniformes	23	China	Gustafsson *et al*. (2021)[b]
Carnivora	55	Netherlands	Hirzmann *et al*. (2021)
Piciformes	2	Manitoba, Canada	Palma & Galloway (2021)
Pelecaniformes	54	Chile	Salazar-Silva (2021)
Anseriformes	28	Manitoba, Canada	Grossi and Galloway (2022)
Suliformes	15	Brazil	Antonello *et al*. (2022)

[a]Some rock pigeons in this study came from rehabilitation hospitals, but the authors did not specify the exact number. [b]This study was conducted in a captive breeding facility and is included here because of the importance of the discovery of the lice infesting the host species.