An Assessment of Feather Mite Presence on Mid-Atlantic Birds and a Call to Banders

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ABSTRACT

Feather vane mites are small arthropods that live permanently on the feathers of birds. They are generally considered to be commensal and not harmful to their host but several aspects of their biology remain to be understood, including their distribution on North American birds. We surveyed 448 birds of 48 species banded in northern Delaware and southeastern Pennsylvania between April and November of 2018 and found that 203 birds (45.8%) belonging to 37 species (77%) had mites on at least one of their wing feathers. Mites were most common on the three outermost primaries and were rarely present on the tail. The peak prevalence was in May when 74% of the 49 birds examined had mites. The prevalence and number of feather mites varied considerably between species but was especially high in Downy Woodpeckers (Dryobates pubescens) *and House Finches* (Haemorhous mexicanus). *This variation deserves further study in order to identify possible phylogenetic, environmental or ecological patterns so we suggest that banders throughout North America examine birds for feather mites to increase our understanding of these creatures.*

INTRODUCTION

Feather vane mites (Acari: Astigmata) are small (<0.5mm) elongate arthropods most commonly found flattened against the vanes of wing feathers (Proctor 2003, Plate 1). They spend their entire life cycle on birds and are thought to be vertically transmitted from parents to their young in the nest (Proctor 2003) although they could, theoretically, be passed between any two individuals which come into contact during copulation, fighting, or feeding, or could be acquired at communal dust baths. Nymphal mites hatch from eggs glued to the feathers and pass through several pale instars before ultimately molting into the eight-legged reproductive adult with a darker-colored hard exoskeleton (Proctor 2003, see Figures 1 and 2). Although they are cold-blooded, they do respond to thermal cues and will move from the wing feathers to be closer to the body if they become chilled (McClure 1989). The effect of feather mites upon their bird hosts has long been uncertain (Proctor 2003). They may be parasites which damage their host by scraping at the feathers to obtain keratin protein, they may be harmless commensals which scavenge on feather debris, or they may even benefit their host by cleaning the feathers of dried oils and residues (Proctor 2003). However, a remarkable recent study (Doña et al. 2018) examined the stomach contents of 18 species of feather mites using microscopy and DNA analyses and found that fungi and possibly bacteria were the main food sources, although there were traces of oils which could be uropgyial gland oil (preen oil). Importantly, the stomachs did not contain any bird blood or skin, suggesting that feather mites are more likely symbionts and could even be beneficial.

A key step toward understanding feather mite biology is identifying whether some birds are more likely to have them than others and, if so, whether any patterns in their distribution between species can be explained, by their phylogeny, ecology or morphology. Several banders have shed light on such patterns by examining the birds they handled for mites. McClure (1989) surveyed a remarkable 47,000 birds of 90 species over an 11-year period in Ventura County, California, (including over 20,000 House Finches (*Haemorhous mexicanus*) and 9,000 White-crowned Sparrows (*Zonotrichia leucophrys*)) and found that 40% had mites on their primary or secondary feathers. More recently, a massive comparative study from seven European countries sampled mites on 119 passerine species of almost 76,000 birds (Diaz-Real et al. 2014) and found that the proportion of individuals with mites was very variable among species but was significantly repeatable. In other words, some species regularly have more mites than others although there was considerable overlap between species due to high variation. In order to add to these data and to stimulate more interest in feather mites among North American banders we collected data on the prevalence (proportion of birds with mites) and incidence (number of mites per bird) of feather mites from birds banded in Delaware and Pennsylvania as part of a study investigating the effect of alien plants on bird communities.

METHODS

Bird banding took place 2-3 mornings per week between April-November at Ashland Nature Center in Hockessin, Delaware, and Bucktoe Creek

Figure 1. Magnified image of feather mites on the innermost primary of a Gray Catbird. There are 3 adult mites and 2 paler nymphal instars facing to the right in the middle of the image and 2 intact eggs and 1 hatched egg near the bottom.

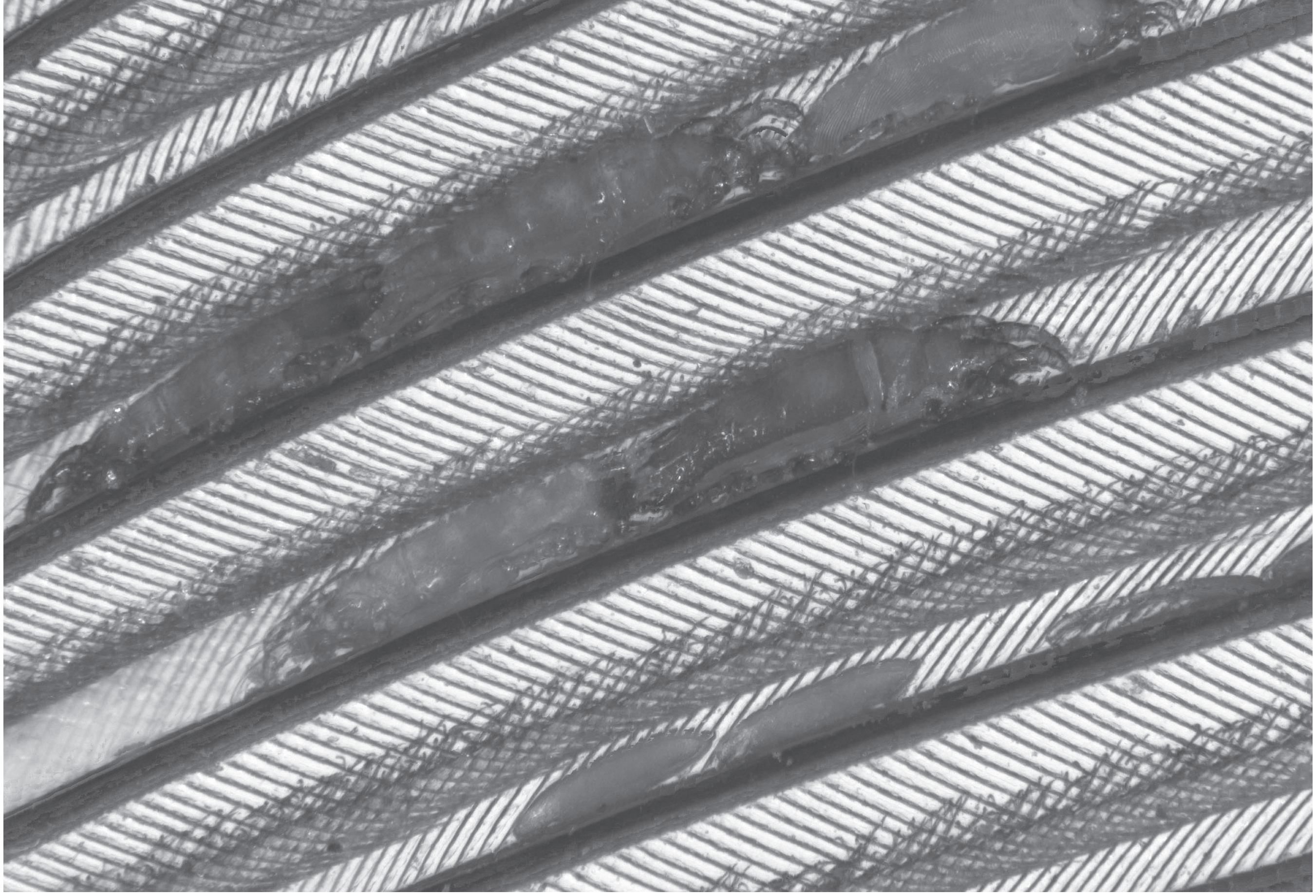

Figure 2. Scanning Electron Microscope image of a Gray Catbird feather mite (facing right).

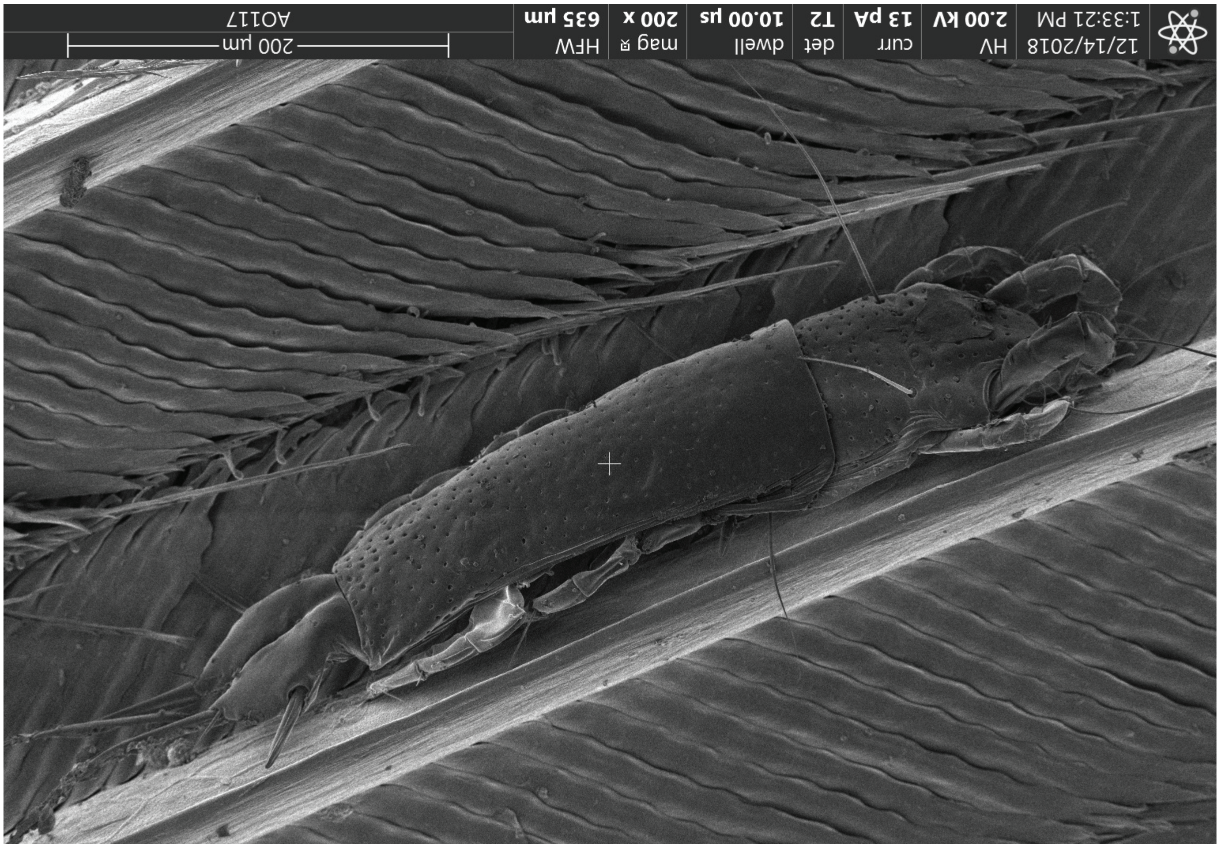

Figure 3. Spread wing of a house finch showing large numbers of feather mites. Primaries 9 and 8 would receive a score of 3, primaries 7,6, 3 and 2 would receive a score of 2, primaries 5,4 and 1 would receive a score of 1.

Preserve near Kennett Square, Pennsylvania. Birds were captured using between one and four 2 x 12 m mist nets from approximately 730-1130 and were identified as to species and banded (by IS) then aged and sexed using Pyle (1997). Birds banded during the fall were aged, where possible as after-hatch year (AHY) or hatch-year (HY) based on plumage characters. Wearing a head-mounted magnifying glass, we then spread open the left wing and held it up to the sunlight to quantify any feather mites present on the underside of the feathers then did the same for the tail. We scored the intensity of feather mites present on each primary (excluding the reduced 10th primary where present), secondary, and tail feather on a simple 0 to 3 scale where 0 = no mites, 1 = a few mites, 2 = a modest amount of mites and 3 = lots of mites (see Figure 3, after McClure (1989). All feathers were scanned by the same observer (IS) and we only used data from the first time a bird was captured to avoid pseudo-replication. In practice, very few birds had feather mites on their tail (see below) so, to condense the incidence of mites from each bird into a single number, we simply summed the mite scores from their 9 primaries and 9 secondaries. Thus, the maximum mite score a bird could receive was 54 (a score of 3 on all 18 flight feathers). We did not collect any mites for identification, but for illustrative purposes we plucked (under license) the innermost primary from a Gray Catbird (*Dumatella carolinensis*) banded in September which was found to have feather mites. Shannon Modla of the University of Delaware, later captured images of these mites using a compound light microscope and a Scanning Electron Microscope.

RESULTS

We examined 448 birds of 48 species and found that 203 birds (45.8%) belonging to 37 species (77%) had feather mites on at least one of their flight feathers. However, for 26 of these species only a small number of birds were examined (< 5) which may introduce sampling errors because parasites often have a negative binomial distribution in which a small number of individuals have many parasites while most have few or none (Southwood 1978). We, therefore, compared the prevalence and incidence of feather mites between the 20 species where at least 5 individuals had been sampled. The five species with the highest prevalence of feather mites were the Dark-eyed Junco (see Table 1 for data and for scientific names), House Finch, Downy Woodpecker, Fox Sparrow and Eastern Towhee (all > 67% of birds), and the five with the lowest prevalence were the Ruby-crowned Kinglet, Common Yellowthroat, White-crowned Sparrow, Carolina Wren and House Wren (all < 15% of birds). The five species with the highest incidence of feather mites were House Finches, Downy Woodpeckers, Tufted Titmice, Indigo Buntings and Fox Sparrows (total mite score all > 7.9), and the five with the lowest were Common Yellowthroats, Ruby-crowned Kinglets, White-crowned Sparrows, Carolina Wren and House Wren (total mite score all < 3.0, Table 1). For these 20 species, the average proportion of primaries with mites was 3.0/9 and the average proportion of secondaries with mites was 2.3/9. Among the primaries, mites were most common on the three outer primaries and least common on the innermost. Mites were more evenly distributed across the secondary feathers though became progressively less common on the tertials (Table 2). The average mite score found on each feather was similar across the primaries and secondaries (Table 2). Only 10 birds had mites on their tail, and most of these were House Finches (n = 7). Furthermore, almost all of these 10 birds also had mites on a high proportion of their primaries (average = 6.3/9) and secondaries (average = 5.3/9) so mites may 'spillover' to the tail in cases of high infestation. The month with the highest prevalence of mites was May, when they were present on 74% of the 49 birds that were handled (Table 3). We only had sufficient data from three species to compare the presence of mites on after-hatching year birds to that of hatching, year birds. In Gray Catbirds and Song Sparrows, mites were equally common on AHY and HY birds (Catbirds: 11/19 AHY vs 7/15 HY, Fisher's Exact Test P = 0.73, Song Sparrows: 6/21 AHY vs 3/18 HY, Fisher's Exact Test P = 0.46). However, there was a non-significant tendency for HY American Goldfinches to be more likely to have feather mites than AHYs (6/19 AHY vs 7/10 HY, P = 0.06).

Table 1. The prevalence (% individuals with feather mites) and average incidence (score of # feather mites per bird) of feather mites on 20 species of birds banded in Delaware and southeastern Pennsylvania. Table sorted in descending order of prevalence.

Species	# Birds	# With Mites	%With Mites	Avg # Primaries with mites	Av # Secondaries with mites	Average Total Mite Score	Scientific names
Dark-eyed Junco	6	6	100.0	3.0	3.2	7.3	*Junco hyemalis*
House Finch	16	15	93.8	6.9	5.9	17.5	*Haemorhous mexicanus*
Downy Woodpecker	10	8	80.0	6.6	5.9	13.5	*Dryobates pubescens*
Fox Sparrow	14	10	71.4	5.2	2.6	7.9	*Passerella iliaca*
Indigo Bunting	6	4	66.7	3.5	2.3	8.0	*Passerina cyanea*
Eastern Towhee	9	6	66.7	3.8	2.7	6.5	*Pipilo erythrophthalmus*
Gray Catbird	58	38	65.5	4.5	1.1	7.5	*Dumetella carolinensis*
American Robin	7	4	57.1	1.8	1.5	4.0	*Turdus migratorius*
White-throated Sparrow	36	20	55.6	1.5	3.9	6.2	*Zonotrichia albicollis*
Eastern Bluebird	6	3	50.0	3.0	3.3	6.3	*Sialia sialis*
Northern Cardinal	20	10	50.0	4.3	0.7	6.0	*Cardinalis cardinalis*
Tufted Titmouse	9	4	44.4	3.0	6.0	11.0	*Baeolophus bicolor*
American Goldfinch	32	12	37.5	2.6	4.2	7.2	*Spinus tristis*
Purple Finch	24	9	37.5	3.9	0.6	4.6	*Haemorhous purpureus*
Song Sparrow	64	16	25.0	4.7	2.2	7.4	*Melospiza melodia*
Ruby-crowned Kinglet	27	4	14.8	0.5	1.8	2.3	*Regulus calendula*
Common Yellowthroat	20	2	10.0	1.0	1.3	3.0	*Geothlypis trichas*
White-crowned Sparrow	10	0	0.0	0.0	0.0	0.0	*Zonotrichia leucophrys*
Carolina Wren	7	0	0.0	0.0	0.0	0.0	*Thryothorus ludovicianus*
House Wren	6	0	0.0	0.0	0.0	0.0	*Troglodytes aedon*

Table 2. The prevalence of incidence of feather mites on each primary (P) and secondary (S) feather from 203 birds of 37 species banded in Delaware and southeastern Pennsylvania that had mites on at least one wing feather.

Feather	P1	P2	P3	P4	P5	P6	P7	P8	P9
Number with mites	61	76	71	80	89	89	108	113	103
% of 203 birds	30	37	34	39	43	43	52	55	50
Average mite score	1.11	1.09	1.15	1.15	1.16	1.21	1.26	1.27	1.19
Feather	S1	S2	S3	S4	S5	S6	S7	S8	S9
Number with mites	69	66	74	71	68	64	54	40	7
% of 203 birds	33	32	36	34	33	31	26	19	3
Average mite score	1.11	1.1	1.11	1.1	1.16	1.25	1.31	1.39	1.63

Table 3. The percentage of birds that were handled for banding each month from April to November that had feather mites.

Month	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov
# with mites/birds handled	0/10	36/49	22/43	11/31	10/30	8/19	58/163	58/103
% with mites	0	74	51	36	33	42	36	56

DISCUSSION

We examined approximately 450 birds of 48 species banded in Delaware and south-eastern Pennsylvania and found that almost half of them carried feather mites. Even allowing for our relatively small sample sizes, there was a measurable amount of variation between species, with feather mites being common and numerous on House Finches and Downy Woodpeckers and yet uncommon and only present in low numbers on Common Yellowthroats and Ruby-crowned Kinglets. The incidence and prevalence of mites were similar across most of the flight feathers although the three outer primaries were the most likely to have mites and the three inner secondaries were the least likely, perhaps because they are smaller (Pyle 1997). Very few birds had mites on their tail, perhaps because mites prefer being on the wing feathers as this means they stay warm when the wings are folded and can retreat to the body more rapidly if they become cold.

We also found a peak prevalence in May which contrasts with the large-sample studies which found a higher percentage of birds with mites during the non-breeding season (e.g. Diaz-Real et al. 2014). None of the birds banded in April had mites, though the sample size was small (n = 10). We only had sufficient data from three species banded in late summer and fall (American Goldfinch, Gray Catbird and Song Sparrow) to compare the prevalence of mites between birds hatched that year and older birds. There was no difference in mite prevalence between AHY and HY Gray Catbird and Song Sparrow, and although a greater proportion of HY American Goldfinch had mites than AHY birds this was non-significant.

A CALL TO BANDERS

Any rigorous study of feather mite distribution has to account for several potentially confounding variables such as the bird's sex, age and molt status, as well as the time of season or local environment. Although these variables might produce spurious relationships, they can be overcome by sample sizes that are large enough to allow the importance of each one to be teased apart. Hence, the secondary purpose of this article is to encourage North American banders to collect data on feather mites, provided the birds' well-being remains the priority. Once one becomes familiar with the technique, the primaries and secondaries can be scanned for mites and the results dictated to an assistant in less than a minute. Even if the numbers of mites on each feather could not be counted or scored because of time constraints, then simply recording mites as being either present or absent would still be useful. Since mites are rarely present on the tail ,this need not be scanned (see also Behnke et al. 1999) and mites are harder to detect here anyway because these feathers are often abraded and ragged, especially on ground-feeding birds.

Given the number of active banders across the continent it should be possible to generate feather mite data from over 10, 000 birds of hundreds of species each year. Although the dataset is likely to be heavily biased toward passerines mist-netted at banding stations, it could include birds from families that have been under-sampled. For example, little is known about the prevalence of feather mites on owls, raptors, seabirds or shorebirds and yet, some of these species are banded in their hundreds if not thousands each year. Hence there is much that could be learned about feather mites through a collaborative effort by North American banders.

Since feather mites may have a negative binomial distribution (e.g., Southwood 1978), we suggest an arbitrary threshold of 100 individuals of each species would provide a reasonable estimate of their true average prevalence. This would allow a collaborative group of researchers to identify whether feather mite prevalence is a species-specific trait (as was found in European passerines by Diaz-Real et al. (2014)) but also how much of the variation occurs at the genus (e.g., *Setophaga* warblers) or family level (e.g., Picidae woodpeckers). Once we have identified the sources of variation in feather mite prevalence and incidence we can begin to test for potential explanatory factors including aspects of morphology (e.g., bill shape or size, body size), behavior (e.g., mating system, extent of male parental care), ecology (e.g., habitat type) or environment (e.g., local ambient temperature, salinity or humidity). For example, a survey of mites on Spanish passerines (Galván et al. 2008) found fewer mites on riparian/marsh birds, though only in resident species during the breeding season. This study could be amplified across North America since birds are probably banded in almost every habitat type present. Furthermore, it should be possible to test for environmental effects upon feather mite numbers within the same host species as there are several birds like House Finches and Song Sparrows which are frequently banded in multiple locations across the continent.

Furthermore, several variables routinely collected during banding would provide simple comparisons that would further our understanding of feather mite biology. First, many of the passerines banded in large numbers each year are sexually dimorphic as adults (e.g. warblers, icterids, finches), which would allow us to compare mite numbers of males and females of the same species. One prediction is that females have more mites than males as they are constantly exchanging them with their nestlings during brooding. Second, many passerines are banded during fall migration when they can often be classified as either HY or AHY, which would allow us to compare mite numbers on birds of different ages. One prediction is that young birds have more mites than adults because they have yet to develop the ability to preen efficiently. Third, many of the species handled at banding stations during spring or fall can be categorized as migrants or presumed residents. One prediction is that migrants have more mites than residents as the energy and time required for migration reduces their ability to remove mites through preening. Resident species are likely to be especially informative as one could collect data on their feather mite numbers throughout the year (including from local recaptures) to test for seasonal effects associated with the breeding season and molt. Molt adds a fascinating dimension to possible age-related differences in mite numbers since HY birds usually do not replace any of their flight feathers during the prebasic molt and yet AHY birds typically replace them all (Pyle 1997), which must present a challenge for any mites present. McClure (1989) noted mites being present on the secondaries but not the primary feathers just as these are about to be dropped, and Pap et al. (2006) found that Barn Swallow (*Hirundo rustica*) feather mites used a ‘last moment’ strategy, moving just before a particular feather was to be dropped.

If time was available and the bird being handled was not stressed, we recommend that banders also measure the size of the uropygial (preen) gland (calculated as length x width x height, with each variable measured using calipers), as this seems relevant to feather mite biology (Proctor 2003). Galván et al. (2008) found a positive association between feather mite abundance and the size of this oil-producing gland in 38 passerine species banded in Spain and Doña et al. (2018) found oily globules in feather mite stomachs which may have been preen oil.

Admittedly, assessing feather mites using the naked eye has its limitations as it does not provide data on the proportion of adults, nymphs and eggs present on each bird but simply pools the age classes together. Nor does it provide information on the composition of mite species present. For example, McClure (1989) recorded the same mite species (*Proctophyllodes polyxenes*) on five different bird species so some mites are presumably transferred between and, well as within species. Nevertheless, the visual surveys are quick and relatively easy to perform and should identify broad patterns given a large enough sample size. We invite banders to collect data on mites using the system described above (following McClure (1989)) of assessing their incidence on each primary and secondary feather. The data could be added to a shared folder with a view to a jointly-authored publication with authorship rank based on the proportion of data contributed. We would be willing to host the folder without an expectation of lead authorship. We firmly believe that if banders from across the continent can collect standardized data on feather mites in addition to the routine data they are already gathering from each bird, we can gain some rapid insights into the biology of these common yet commonly-overlooked creatures.

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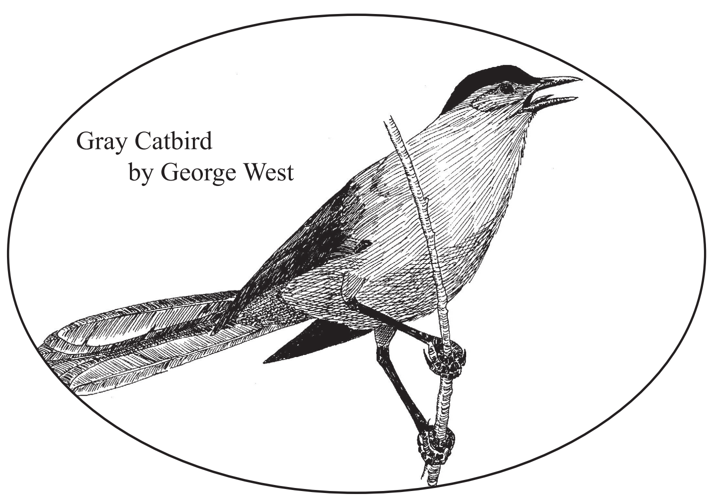
APPENDIX

Species in which 5 or fewer birds were sampled for feather mites (# with mites/# examined)

Red-bellied Woodpecker (Melanerpes carolinus) 3/3,
Acadian Flycatcher (Empidonax virescens) 0/1,
Willow Flycatcher (Empidonax traillii) 1/4,
Eastern Phoebe (Sayornis phoebe) 1/1,
Carolina Chickadee (Poecile carolinensis) 2/4,
Tree Swallow (Tachycineta bicolor) 1/1,
Barn Swallow (Hirundo rustica) 1/1,
Golden-crowned Kinglet (Regulus satrapa) 0/1,
White-breasted Nuthatch (Sitta carolinensis) 0/1,
Brown Creeper (Certhia americana) 1/1,
Brown Thrasher (Toxostoma rufum) 1/2,
Northern Mockingbird (Mimus polyglottos) 2/2,
Veery (Catharus fuscescens) 0/1,
Swainson's Thrush (Catharus ustulatus) 3/3,
Pine Siskin (Spinus pinus) 3/5,
Chipping Sparrow (Spizella passerina) 1/1,
Field Sparrow (Spizella pusilla) 2/4,
Lincoln's Sparrow (Melospiza lincolnii) 1/4,
Swamp Sparrow (Melospiza georgiana) 0/2,
Orchard Oriole (Icterus spurius) 1/4,
Red-winged Blackbird (Agelaius phoeniceus) 1/3,
Ovenbird (Seiurus aurocapilla) 2/3,
Northern Waterthrush (Parkesia noveboracensis) 0/1,
Mourning Warbler (Geothlypis philadelphia) 0/1,
Magnolia Warbler (Setophaga magnolia) 0/1,
Black-throated Blue Warbler (Setophaga caerulescens) 3/5,
Palm Warbler (Setophaga palmarum) 0/2,
Yellow-rumped Warbler (Setophaga coronata) 1/3


Gray Catbird by George West