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Ecological correlates of ectoparasitism on Atlantic Forest birds, Brazil

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RESUMO. **Correlações ecológicas de ectoparasitismo em aves da Floresta Atlântica, Brasil.** Populações de espécies nativas podem ser completamente ou parcialmente destruídas por doenças naturais ou transmitidas por animais domésticos. Avaliamos aqui a prevalência de ectoparasitas em aves da região da Serra do Mar da Floresta Atlântica, Paraná, Brasil, procurando por potenciais vetores de doenças, como carrapatos hematófagos (Acari), malófagos (Phthiraptera) e ácaros de penas (Acari: Analgoidea). A prevalência destes ectoparasitas foi analisada em relação a: (1) variáveis ambientais (sazonalidade e altitude); (2) ecologia das aves (participação em bandos mistos, tipo de ninho e guilda de forrageamento, e (3) taxonomia e massa corporal. Examinamos aves durante dois invernos (Julho-Agosto de 1991 e Julho de 1995) e dois verões (Fevereiro de 1992 e 1993) em duas florestas de montanha. Durante os mesmos invernos também examinamos aves em uma floresta baixo-montana. A prevalência de ectoparasitas foi maior durante os invernos do que durante os verões, mas foi geralmente semelhante nas florestas de montanha e de baixada. A prevalência de carrapatos e de malófagos em Passeriformes variou consideravelmente, e independentemente uma da outra, entre as famílias de aves. Dieta foi um fraco preditor da prevalência de carrapatos, entretanto a prevalência de carrapatos para insetívoros de casca de árvores (84.2 %) foi pelo menos duas vezes maior do que de qualquer outra guilda de forrageamento. Participantes regulares de bandos mistos possuiram maiores prevalências de carrapatos (57.8 %) do que participantes irregulares (35.0 %). Nenhuma diferença na prevalência de carrapatos foi detectada entre espécies que fazem ninhos abertos ou fechados. A massa corporal não esteve significativamente correlacionada com intensidade de infestação por carrapatos em quatro espécies de aves testadas. Várias espécies de aves endêmicas da Floresta Atlântica tiveram altas prevalências de ectoparasitas demonstrando um grande potencial de infestação por doenças.
PALAVRAS-CHAVE: bandos mistos, carrapatos, dieta, ectoparasitas, ninho, Floresta Atlântica, Paraná.

ABSTRACT. Wildlife populations may be completely or partially destroyed by naturally borne or diseases transmitted by domestic animals. Here, we evaluate ectoparasite prevalence on birds from the Serra do Mar region of the Atlantic Forest, in the state of Paraná, Brazil. We searched for potential disease vectors, such as hematophagous ectoparasitic ticks (Acari), chewing lice (Phthiraptera) and feather-mites (Analgoidea). The prevalence of these ectoparasites was analyzed in relation to: (1) environmental variables (seasonality and altitude); (2) host ecology (participation in mixed-species flocks, nest type and foraging guild); and (3) host taxonomy and body mass. We examined birds during two winters (July-August 1991 and July 1995) and two summers (February 1992 and 1993) at two mountain forest sites. During the same winters we also examined birds in a lowland forest. Ectoparasite prevalence was higher during winters than during summers but was usually similar in montane and lowland forests. Tick and chewing lice prevalence on Passeriformes varied considerably, independently of each other, among bird families. Diet alone is a poor predictor of tick prevalence, but prevalence on bark insectivores (84.2 %) was at least twice as high as any other foraging guild. Regular mixed-species flock participants had higher tick prevalence (57.8 %) than irregular participants (35.0 %). No difference in tick prevalence was detected between open and closed nesting species. Body mass was not correlated with infestation intensity in the four species tested. Several endemic birds of the Brazilian Atlantic Forest region showed high ectoparasite prevalence with a strong potential for infestation by diseases.
KEY WORDS: Atlantic Forest, diet, ectoparasites, mixed-species flocks, nests, Paraná, ticks.

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The neotropical region is being deforested rapidly before several basic aspects of the ecology of its organisms are documented. With high deforestation rates, there is an increase in contact between domestic and wild organisms potentially exposing all species to new diseases. Snyder *et al.* (1985), for example, reported that the Mauritius Pink Pigeon (*Columba mayeri*) can contract the fatal herpes virus from apparently healthy Domestic Pigeons (*Columba livia*). Among mammals, populations of the Black-footed Ferret (*Mustela nigripes*) (Thorne and Williams 1988) and lions from the Serengeti National Park in Tanzania (Morell 1994) have already been affected by the canine distemper, which can be transmitted by domestic dogs. The lion example shows that organisms living in protected areas are not immune to infections by parasites.

Ectoparasites may decrease birds' reproductive success (review in Lehmann 1993) by increasing mortality rates or decreasing development rates of nestlings (Foster 1968, Moss and Camin 1970, Chapman and George 1991), or increasing nest desertion by parents (Moss and Camin 1970, Feare 1976, Duffy 1983), or decreasing the ability to attract mates (Clayton 1990). A decrease in survival or body condition of adult birds may also occur, causing death by the loss of sight (Thomas 1941, Worth 1942), anemia (Olson 1935), or general condition (Putzig 1939). Besides such direct effects, ectoparasites may serve as disease vectors for birds (Feare 1976, Clifford *et al.* 1980, Bennett *et al.* 1987) or as intermediate hosts for endoparasites (review in Clayton 1990). Several Neotropical passerines, for example, have been found to host blood haemoproteids (Bennett and Borrero 1976, Bennett *et al.* 1987).

Also, parasite infestations have been correlated with several factors, including climatic seasonality, bird body size or mass, foraging behavior, home range size, living group size, and taxonomy (Randolph 1975, Davies *et al.* 1991, Pruett-Jones and Pruett-Jones 1991).

The ectoparasites of Neotropical birds are poorly studied. Guimarães (1945) described ectoparasites of birds and mammals from the lowlands of Paraná, Brazil. Perez and Atyeo (1984) studied feather mites of Mexican parrots, and Berla (1958, 1973) described feather mites of Brazilian birds. A study of chewing lice on birds of the Neotropical region was conducted in Amazonian Peru by Clayton *et al.* (1992). Oniki and Willis (1991, 1993) reported ectoparasites of birds from Colombia and Minas Gerais, Brazil. Within the Atlantic Forest region of Brazil, ectoparasites have been studied mostly on mammals (see references in Linardi *et al.* 1991 and Barros *et al.* 1993), and to a lesser extent on birds (Arzua *et al.* 1994 and references). More studies of the region are needed, especially considering the high levels of bird endemism and deforestation (McNeely *et al.* 1990).

In this paper, our primary objective is to evaluate the potential danger of disease infestation of birds by estimating ectoparasitism levels by hematophagous ectoparasitic ticks (Acari), chewing lice (Insecta: Phthiraptera, formerly Mallophaga), feather-mites (Analgoidea) and hummingbird flower mites (Gamasida) on Atlantic Forest birds.

Previous studies in the Atlantic Forest region (Linardi *et al.* 1991, Barros *et al.* 1993, Arzua *et al.* 1994 and references) lacked comparisons between ectoparasite prevalence and host ecology. Our second objective, thus, is to evaluate which group of birds would be most likely to be infested by correlating tick prevalence with: 1) environmental variables (seasonality and altitude), 2) host ecology (participation in mixed-species flocks, nest type and foraging guild) and 3) host taxonomy. Also, the potential negative effect of tick infestations on bird fitness is evaluated by correlating bird body mass with tick infestation intensity.

METHODS

Study sites. The first study site where we sampled birds is in Mananciais da Serra (25°30'S, 48°57'W), within the "Área Especial de Interesse Turístico do Marumbi," Piraquara county, in Paraná, Brazil. This study site (a dense montane cloud forest), located at ≈ 1,000 m (a.s.l.), lies on the western slope of the 'Serra do Mar' mountain ridge, within a ≈ 70,000 ha mostly contiguous forest (ITCF 1987). Here, we sampled two areas 500 m apart: (1) a patch of primary forest with a continuous 25-m high canopy, open understory, patches of 10-m high bamboo (Poaceae) and high numbers of epiphytes; and (2) a patch of disturbed 15-m high forest dominated by *Tibouchina sellowiana* (Melastomataceae) with canopy broken by emergents, and dense understory dominated by small bamboo (*Chusquea* sp.: Poaceae).

The second study site we sampled is at Banestado Reflorestadora (25°38'S, 48°30'W), Paranaguá county, also in Paraná. It consists of a 488 ha lowland (≈ 50 m a.s.l.) dense forest, with a 15-m high continuous canopy, and open understory managed for palm-heart (*Euterpe edulis*: Arecaceae).

Mist-netting and ectoparasite sampling. Birds were captured with mist-nets (mostly between 07:00 and 14:00) during two summers (February 1992 and 1993), and two winters (July-August 1991 and August 1995) at Mananciais da Serra, and during the same two winters at Banestado Reflorestadora. We used 15 to 17 mist-nets (mesh 36 mm, 2.5 m high x 12 m long) on linear transects within each area. At the montane forest we sampled birds at a small patch of primary forest and at a patch of disturbed forest. During the winter of 1995 we also sampled birds at the montane forest at a third site. This area was 1.5 km away from the others, similar, but more disturbed, than the primary forest site.

Each captured bird received a metal band (provided by CEMAVE/IBAMA, Brazil), was weighed with 50 or 100 g Pesola spring scales and measured. Hematophagous ectoparasitic ticks were sampled quantitatively more intensively on the birds' neck and head by blowing on feathers. We considered as new records ticks on banded birds recaptured at an interval of at least 30 days, because ticks usually do not stay on their hosts for more than two-three weeks

(Pruett-Jones and Pruett-Jones 1991). Tick prevalence (proportion of individuals of a taxon infested) and infestation intensity (mean number of ticks among the individuals of a taxon, including individuals not infested) was calculated for all species and bird families for the winter study periods (Appendix).

Feather-mites were sampled qualitatively by inspecting the birds' head feathers and viewing the wing and tail feathers backlit against the sky. Chewing lice occurred mostly on the neck and head where we concentrated our qualitative samples. Chewing lice and hummingbird flower mites were sampled only during the winter of 1995. Ectoparasites were collected with forceps from the body and feathers of 54 birds of 32 species during 1991 and 1992 and preserved in 70 % alcohol.

Species' diet, nesting behavior, and participation in mixed species flocks followed the literature (Davis 1946, Sick 1985, Ridgely and Tudor 1989) and personal observations by the authors. Bird names follow Sibley and Monroe (1990).

Statistical analyses. The random distribution of ectoparasites on the birds was compared between the variables tested with a contingency test for χ^2 with Yates correction for continuity (χ_Y^2) whith one degree of freedom. The Mantel-Haenszel χ^2 test (χ_{M-H}^2) was applied in cases when two samples of the same treatment were not homogeneous. We conducted Spearman rank correlations (r_s) between body mass and tick infestation intensity for species with more than 10 records and a high range of ticks per host species.

RESULTS

Non-Passeriformes were rare in our captures (four captures during winter, 10 captures during summer), with the exception of hummingbirds, which had 44 individuals of five species sampled during the winter of 1995. For this reason we analyze Passeriformes and hummingbirds separately, excluding the other species. We sampled a total of 313 individuals of 53 species of Passeriformes during winter, and a total of 184 individuals of 51 species during summer (Appendix).

Ectoparasite identification. Ticks (n = 129) collected on 54 birds during the winter of 1991 showed a high abundance (n = 120) of *Amblyomma* sp. larvae, and one nymph of *Ixodes* sp. Of the eight collected during the summer of 1992, seven were *Ixodes* sp. nymphs and one was an *Amblyomma* sp. larvae. Feather-mites belonged to the super-family Analgoidea (Proctophyllodidae).

Even though we did not search systematically for haematophagous diptera (Hippoboscidae), some occurred sporadically on the birds (White-browed Foliage-gleaner, *Anabacerthia amaurotis*, Buff-browed Foliage-gleaner, *Syndactyla rufosuperciliata,* Rufous-capped Spinetail, *Synallaxis ruficapilla*, Greenish Manakin, *Schiffornis virescens* and Golden-crowned Warbler, *Basileuterus culicivorus* in 1991, Barred Forest-Falcon, *Micrastur ruficollis*, White-shouldered Fire-eye, *Pyriglena leucoptera*, Rufous Gnateater, *Conopohaga lineata,* and *Schiffornis virescens* in 1992 and Plain Antvireo, *Dysithamnus mentalis* in 1995) and are not considered further here.

Year-to-year variations. Ectoparasite prevalence differed significantly between years during the summers but not during the winters. Both tick (χ_Y^2 = 4.158; df = 1; P = 0.041) and feather-mite (χ_Y^2 = 18.725; df = 1; P = 0.000) prevalence varied significantly between years at the montane forest during the summer (table 1). Tick prevalence, however, had similar values during the winters, both at the lowland (χ_Y^2 = 2.415; df = 1; P = 0.120) and at the montane (χ_Y^2 = 1.519; df = 1; P = 0.218) forests.

Seasonality. Ectoparasite prevalence was higher during the winters than during the summers. For Passeriformes, tick prevalence was significantly higher, on the average, during the winter than during the summer (χ_{M-H}^2 = 53.436; df = 1; P < 0.000) at the montane forest (table 1). Tick prevalence was 3.5 times higher and tick prevalence on species was nearly two times as high during the winter than in the summer (table 1).

Feather-mites were also significantly (χ_{M-H}^2 = 17.888; df = 1; P < 0.000) more prevalent during the winter of 1995 than the average of the summers at the montane forest.

Altitude. Lowland and montane forests usually had similar ectoparasite prevalence. The average tick prevalence at the montane forest was not different (χ_{M-H}^2 = 0.852; df = 1; P = 0.356) from the average tick prevalence at the lowland forest during the winters (table 1). The same pattern was observed for feather-mites (Fisher Exact test, P = 0.764), but chewing lice showed significantly higher (χ_Y^2 = 10.502; df = 1; P = 0.001) prevalence at the lowland than at the montane forest during the winter of 1995 (table 1).

Tick infestations during winters

We combined the 311 winter samples from the lowland and montane forests to conduct comparisons of tick prevalence with diet, type of participation in mixed-species flocks and nest type. The restricted samples of the other ectoparasites and of our summer samples limit statistical analysis and weaken conclusions for these data sets.

Taxonomy. Since only 10 species had more than 10 individuals sampled we restrict our taxonomic analysis to the family level. The number of species and individuals infested by ticks differed considerably among bird families (Appendix) during the winter. The highest prevalences were recorded for Dendrocolaptidae (85.3 %) and Furnariidae (61.4 %), and the lowest for Parulidae (5.6 %). All other families had intermediate values or too little data to justify conclusions. Infestation intensity at the family level followed the same pattern of prevalence with the highest mean infestations for Dendrocolaptidae (7.4 ticks/bird) and Furnariidae (3.9 ticks/bird). The two most infested birds were one Furnariidae (*A. amaurotis*) with 57 ticks, and one Dendrocolaptidae (Lesser Woodcreeper, *Lepidocolaptes*

TABLE 1. Prevalence [number of birds examined (% infested)] of ticks, feather-mites and chewing lice on Passeriformes of the Atlantic Forest, at lowland and montane sites, during winters (1991 and 1995) and summers (1992 and 1993).

		Season/Year					
		Winter			Summer		
Ectoparasite	Altitude	1991	1995	Total	1992	1993	Total
Ticks	Lowland	29 (27.6)	34 (50.0)	63 (39.7)	-	-	-
	Montane	133 (50.4)	115 (41.7)	248 (46.4)	108 (8.3)	76 (19.7)	184 (13.0)
	Total	162 (46.3)	149 (43.3)	311 (45.7)	108 (8.3)	76 (19.7)	184 (13.0)
Feather-mites	Lowland	-	34 (91.2)	34 (91.2)	-	-	-
	Montane	-	116 (87.9)	116 (87.9)	108 (28.7)	76 (61.8)	184 (42.4)
	Total	-	150 (88.7)	150 (88.7)	108 (28.7)	76 (61.8)	184 (42.4)
Chewing lice	Lowland	-	34 (91.2)	34 (91.2)	-	-	-
	Montane	-	116 (59.5)	116 (59.5)	-	-	-
	Total	-	150 (66.7)	150 (66.7)	-	-	-

fuscus) with 49 ticks.

None of the bird families had low prevalence of feather mites, with all values ranging from 70.0 % on Formicariidae to 95.5 % on Turdidae (see Appendix). Chewing lice prevalence varied considerably among bird families, with Fringillidae being the least infested (25.0 %) and Turdidae being the most (95.5 %).

Foraging guild. Tick prevalence was much higher on bark insectivores than in any other guild of passerines during the winters (table 2). The six species of bark insectivores had, on the average, high tick prevalence (84.2 %), and high mean infestation intensity (6.8 ticks per host). Insectivores in general and omnivores had higher prevalence (50.0 and 42.2 % respectively) than frugivores and granivores. Tick prevalence, however, varied considerably among insectivore families and species (Appendix).

Flock participation and nest type. The correlates of tick prevalence with type of participation in mixed-species flocks and nest type was analyzed jointly for insectivores and omnivores, since these two groups showed similar prevalence rates ($\chi_Y^2 = 0.699$; df = 1; P = 0.403).

Birds that participated regularly in mixed-species flocks had significantly higher ($\chi_{M\text{-}H}^2$ = 11.314, d.f. = 1, P = 0.001) prevalence than birds with irregular participation. Birds that build closed nests had similar ($\chi_{M\text{-}H}^2$ = 0.405, d.f. = 1, P = 0.525) prevalence to birds that build open nests. These two characteristics are confounded, however, by the significant ($\chi_{M\text{-}H}^2$ = 30.306, d.f. = 1, P < 0.000) association between nest type and flock participation, since most species that build closed nests also participate in mixed species flocks (table 3).

Body mass vs. infestation intensity. Body mass of birds during the winter was not affected by infestation intensity (tick load). We tested the effect of infestation intensity on the body mass with the four species that had more than 10 records and a high range of ticks. Parasitism by ticks did not affect significantly any of the four species tested [*L. fuscus*, (r_s = - 0.005, N = 15, NS), Olivaceous Woodcreeper, *Sittasomus griseicapillus* (r_s = 0.158, N = 11, NS), *A. amaurotis* (r_s = - 0.059, N = 28, NS), and *S. rufosuperciliata* (r_s = - 0.306, N = 13, NS)].

Hummingbird ectoparasitism

We never recorded ticks and haematophagous Diptera on hummingbirds, but the three other ectoparasites (flower mites, chewing lice and feather mites) occurred in all five species of hummingbirds sampled during the winter of 1995. Hummingbird flower mites varied considerably in prevalence among the three most common host species (table 4), being almost always (92.3 %) present on the Scale-throated Hermit, *Phaethornis eurynome*, common (60.0 %) on the Violet-capped Woodnymph, *Thalurania glaucopis*, but rare (8.3 %) on the Brazilian Ruby, *Clytolaema rubricauda*. Chewing lice varied less (33.3-60.0 %) among the three most common hosts. Feather-mites were almost always (93.2 %) present on hummingbirds, with the lowest prevalence reported for *P. eurynome* (76.9 %). Of the 44 hummingbirds sampled for the three ectoparasites, 14 (31.8 %) had triple infestation, 19 (43.2 %) had double infestation, 11 (25.0 %) had single infestation, and no hummingbird was ever free of ectoparasites.

DISCUSSION

The most evident pattern detected is that ectoparasite prevalence is higher during winters than during summers (table 1). This pattern is probably related to the annual cycles and natural history of the parasites. Ectoparasite prevalence was not homogeneous between years, seasons and forests at different altitudes (table 1). These findings suggest complex spatial and temporal population dynamics of ectoparasites on their hosts.

Tick prevalence on Passeriformes varied considerably among families and was related to foraging guild and type of participation in mixed-species flocks (tables 2 and 3). Bark insectivores were the most infested, with prevalence even higher than terrestrial foragers (table 2), which are expected to be more infested by ticks which wait on the litter. Insectivores and omnivores were infested much more than frugivores and granivores, but the variation among the insectivore families was as great as the variation between insectivores and frugivores (Appendix). Thus, diet alone is a poor correlate of tick prevalence.

The association between nest type and flock participation (table 3) may be explained by the characteristics of two families (Dendrocolaptidae and Furnariidae which participate in mixed-species flocks, and build closed nests) most represented in the samples. Even though birds of the Paraná region do not reproduce during the winter, nesting behavior may be related with roosting behavior.

TABLE 2. Number of species and of individuals (% infested) examined, and infestation intensity of ticks on Passeriformes captured during the winters by guild (foraging substrate and diet).

Guild	Number of species	Number of birds examined (% infested)	Mean (range) infestation intensity
Terrestrial (Insectivore)	5	13 (38.5)	1.5 (0-8)
Bark (Insectivore)	6	38 (84.2)	6.8 (0-49)
Arboreal	42	260 (40.4)	1.6 (0-57)
Insectivore	26	175 (43.4)	1.9 (0-57)
Omnivore	9	45 (42.2)	1.1 (0-10)
Frugivore	5	26 (26.9)	0.9 (0-8)
Granivore	2	14 (21.4)	1.1 (0-8)
All insectivores	37	226 (50.0)	2.7 (0-57)

TABLE 3. Prevalence [number of birds examined (% infested)] of ticks on Passeriformes during the winters, in relation to their participation in mixed species flocks (regular vs. irregular), diet [insectivore, omnivore and plant eater (frugivore + granivore)] and nest type (closed vs. open).

Participation in mixed species flocks	Diet	Nest type: Closed	Nest type: Open	Total
Regular	Insectivore	111 (63.1)	10 (40.0)	121 (61.2)
	Omnivore	6 (16.7)	6 (50.0)	12 (33.3)
	Plant	1 (0)	1 (0)	2 (0)
	Total	118 (60.2)	17 (41.2)	135 (57.8)
Irregular	Insectivore	78 (32.1)	27 (51.9)	105 (37.1)
	Omnivore	0 (0)	33 (39.4)	33 (39.4)
	Plant	0 (0)	38 (26.3)	38 (26.3)
	Total	78 (32.1)	98 (37.4)	176 (35.0)
Total		196 (49.0)	115 (37.9)	311 (45.7)

Dendrocolaptidae, for example, nest and roost in trunk cavities (Oniki 1970, Skutch 1989), and Furnariidae may roost in their closed nests (Sick 1985).

Species that participate regularly in mixed-species flocks had higher prevalence than irregular participants (table 3). The positive benefits of participating in mixed-species flocks may be counterbalanced by potential negative direct or indirect effects of ectoparasitism (review in Lehmann 1993). Ectoparasitism may still be considered an important factor in the evolution of mixed-species flock participation behavior even though no negative fitness (loss of body mass) effect was detected here. Alternatively, if flock species are transmitting ectoparasites to other flock species (cross-species infection) they can benefit by indirectly excluding the flock competitors (see Holt 1993).

Lice prevalence on birds may vary considerably among Neotropical forests. Our lice estimate for Passeriformes during the winter was of 66.7 %, a value 40 % higher than that reported by Clayton *et al.* (1992) in Amazonian Peru. This difference may be related, however, to the fact that their samples were taken during summer and winter and that they included both Passeriformes and Non-Passeriformes.

The community of ectoparasites on hummingbirds differed from Passeriformes, by the lack of ticks and haematophagous flies and the presence of flower mites on hummingbirds. Oniki and Willis (1991) also did not encounter ticks on eight hummingbird species from Colombia. Among the ectoparasites found on hummingbirds, flower mites showed the most interesting pattern, varying in prevalence among hummingbird species. The ecology and coevolution of flower mites and hummingbirds was studied in detail by Colwell (1973, 1995 and references). *Phaethornis* spp. and the Saw-billed Hermit (*Ramphodon naevius*), seem to have a very close association with flower mites, deserving further studies.

The fact that few ticks were found on body parts besides the birds' heads and necks suggests that either the birds clean ectoparasites or the ectoparasites select attachment sites [see Choe and Kim (1989) for feather mites]. The first hypothesis is supported by Boyd's (1951) finding of fleas and lice in bird stomachs. Preening is considered the primary defence of hosts against lice (Waage 1979, Clayton 1991). Besides the self-grooming behavior, some birds exhibit allopreening (reviews in Cullen and Ashmole 1963, Harrison 1965). Brooke (1985), for example, demonstrated that penguin pairs have less ectoparasites than unmated individuals, possibly because of allopreening by the pair. It is not known how much allopreening occurs in the Passeriformes studied here.

Implications for Conservation Biology

Several endemic birds of the Brazilian Atlantic Forest region showed high ectoparasite prevalence with a strong potential for infestation by diseases. Prevalence of the ectoparasites sampled was high for some groups of parasites (e.g. 88.7 % for feather mites during the winters) or for specific host taxons (e.g. 85.3 % for ticks on Dendrocolaptidae, or 95.5 % for chewing lice on Turdidae). Lack of similar studies prevents us from evaluating whether these proportions are within natural levels or higher than levels whithin which birds of the region evolved. The montane and lowland sites sampled are not pristine habitat, since forests are variably disturbed and domestic animals such as fowl, dogs, cats and others live nearby. This contact between domestic animals and wildlife may have altered the original prevalence of parasites. Case studies showing domestic-wildlife transmission raise concerns about whether endangered or endemic bird species that live in the Paraná region (e.g. *A. amaurotis*, Spadebill *Platyrinchus leucoryphus*, Azure-shouldered Tanager *Thraupis cyanoptera*, Blackish-blue Seedeater *Amaurospiza moesta*, and Uniform Finch *Haplospiza unicolor*) are under threat of dangerous parasitic infection. Mixed-species flock participants, specially Dendrocolaptidae and Furnariidae, should be more endangered of being infested by an ectoparasite transmitted

TABLE 4. Prevalence [number of birds examined (% infested)] of flower mites (Gamasida), chewing lice (Phthiraptera) and feather mites (Analgoidea) in hummingbirds of the Paraná Atlantic Forest, Brazil, during the winter of 1995.

Species	Number examined	Number (%) infested		
		Flower mites	Chewing lice	Feather mites
Phaethornis eurynome	13	12 (92.3)	7 (53.9)	10 (76.9)
Phaethornis squalidus	1	1 (100)	1 (100)	1 (100)
Thalurania glaucopis	15	9 (60.0)	9 (60.0)	15 (100)
Clytolaema rubricauda	12	1 (8.3)	4 (33.3)	12 (100)
Ramphodon naevius	3	3 (100)	3 (100)	3 (100)
Total	44	26 (59.1)	24 (54.6)	41 (93.2)

disease than irregular flock participants. Several endemic Atlantic Forest species (Appendix) already show high prevalence of one or more ectoparasites (e.g. *A. amaurotis* had prevalence rates of 92 % for feather-mites, 83 % for ticks and 75 % for chewing lice), and we do not know the potential danger of these infestation levels to wildlife. This possible danger (see also Kirkwood 1993, Aguirre and Starkey 1994) should be evaluated further as a background for conservation and management programs of endangered species.

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APPENDIX

Prevalence [number of birds examined (% infested)], relative infestation intensity and range of ticks (Acari), and prevalence number of birds examined (% infested)] of feather mites (Analgoidea) and chewing lice (Phthiraptera) on birds of the Paraná Atlantic Forest, Brazil, during the winters of 1991 and 1995.

	Ticks			Feather mites	Chewing lice
Family-Subfamily (No.)/Bird species	Number examined (% infested)	Infestation intensity	Range ectop.	Number examined (% infested)	Number examined (% infested)
Dendrocolaptidae (5)	34 (85.3)	7.4	0-49	14 (92.9)	14 (35.7)
Lepidocolaptes fuscus	15 (80.0)	9.1	0-49	5 (100)	5 (40.0)
Sittasomus griseicapillus	11 (100)	6.0	1-16	4 (100)	4 (25.0)
Dendrocolaptes platyrostris	3 (100)	12.7	5-23	1 (100)	1 (100)
Dendrocincla fuliginosa	3 (33.3)	1.0	0-3	3 (66.7)	3 (33.3)
Campylorhamphus falcularius	2 (100)	4.0	3-5	1 (100)	1 (100)
Furnariidae (9)	70 (61.4)	3.9	0-57	27 (92.6)	27 (81.5)
Anabacerthia amaurotis	29 (82.8)	6.4	0-57	12 (91.7)	12 (75.0)
Syndactyla rufosuperciliata	13 (61.5)	4.8	0-17	5 (100)	*5 (100)*
Synallaxis ruficapilla	13 (30.8)	0.5	0-4	5 (100)	5 (80.0)
Heliobletus contaminatus	4 (75.0)	1.8	0-5	-	-
Xenops minutus	3 (33.3)	1.3	0-4	-	-
Philydor rufus	3 (33.3)	0.3	0-1	1 (0)	1 (0)
Automolus leucophthalmus	3 (66.6)	0.7	0-1	2 (100)	2 (100)
Lochmias nematura	1 (0)	0.0	0	1 (100)	1 (100)
Sclerurus scansor	1 (0)	0.0	0	1 (100)	1 (100)
Formicariidae (7)	24 (50.0)	1.5	0-11	10 (70.0)	10 (30.0)
Conopophaga lineata	9 (44.4)	1.2	0-4	3 (100)	3 (0)
Dysithamnus mentalis	6 (50.0)	1.5	0-4	4 (75.0)	4 (50.0)
Drymophila malura	5 (60.0)	2.8	1-11	1 (0)	1 (0)
Drymophila squamata	1 (100)	2.0	2	-	-
Chamaeza ruficauda	1 (0)	0.0	0	-	-
Grallaria varia	1 (100)	8.0	8	1 (0)	1 (100)
Myrmotherula gularis	1 (0)	0.0	0	1 (100)	1 (0)
Cotingidae (1)	4 (0)	0.0	0	2 (100)	2 (0)
Carpornis cucullatus	4 (0)	0.0	0	2 (100)	2 (0)
Pipridae (2)	26 (34.6)	1.2	0-8	14 (92.9)	14 (85.7)
Chiroxiphia caudata	19 (31.6)	1.2	0-8	10 (90.0)	10 (90.0)
Schiffornis virescens	7 (42.9)	1.4	0-6	4 (100)	4 (75.0)
Tyrannidae (13)	57 (40.4)	0.7	0-9	28 (85.7)	28 (57.1)
Hemitriccus obsoletus	19 (52.6)	2.5	0-9	8 (100)	8 (62.5)
Hemitriccus nidipendulus	1 (100)	3.0	3	-	-
Hemitriccus diops	1 (0)	0.0	0	-	-
Platyrinchus mystaceus	8 (62.5)	0.9	0-2	6 (66.7)	6 (16.7)
Platyrinchus leucorhyphus	1 (0)	0.0	0	-	-
Todirostrum plumbeiceps	5 (20.0)	0.2	0-1	2 (0)	2 (0)
Mionectes rufiventris	5 (0)	0.0	0	4 (100)	4 (100)
Myiobius barbatus	4 (25.0)	0.3	0-1	1 (100)	1 (100)
Tolmomyias sulphurescens	4 (25.0)	0.3	0-1	2 (100)	2 (100)
Phylloscartes ventralis	3 (0)	0.0	0	1 (100)	1 (0)
Phylloscartes difficilis	1 (0)	0.0	0	-	-
Leptopogon amaurocephalus	3 (66.6)	1.3	0-3	2 (100)	2 (100)
Attila rufus	2 (100)	3.0	2-4	2 (100)	2 (50.0)

APPENDIX

(continued)

Family-Subfamily (No.)/Bird species	Ticks			Feather mites	Chewing lice
	Number examined (% infested)	Infestation intensity	Range ectop.	Number examined (% infested)	Number examined (% infested)
Turdidae (3)	28 (50.0)	0.8	0-7	22 (95.5)	22 (95.5)
Turdus albicollis	22 (54.6)	1.2	0-7	16 (100)	16 (93.8)
Turdus rufiventris	4 (0)	0.0	0	3 (100)	3 (100)
Platycichla flavipes	3 (0)	0.0	0	3 (66.7)	3 (100)
Vireonidae (2)	7 (42.9)	1.9	0-10	4 (100)	4 (75.0)
Cyclarhis gujanensis	4 (50.0)	2.7	0-10	3 (100)	3 (66.7)
Hylophilus poecilotis	3 (33.3)	0.7	0-2	1 (100)	1 (100)
Parulidae (2)	37 (5.4)	0.08	0-2	14 (85.7)	14 (71.4)
Basileuterus leucoblepharus	23 (4.4)	0.09	0-2	12 (83.3)	12 (75.0)
Basileuterus culicivorus	13 (7.7)	0.08	0-1	2 (100)	2 (100)
Thraupinae (6)	9 (44.4)	1.4	0-8	7 (71.4)	7 (71.4)
Tangara desmaresti	3 (33.3)	0.3	0-1	3 (100)	3 (33.3)
Trichothraupis melanops	2 (50.0)	1.5	0-3	2 (0)	2 (100)
Tachyphonus coronatus	1 (100)	8.0	8	-	-
Euphonia pectoralis	1 (0)	0.0	0	-	-
Thraupis cyanoptera	1 (100)	1.0	1	1 (100)	1 (100)
Habia rubica	1 (0)	0.0	0	1 (100)	1 (100)
Fringillinae (3)	15 (20.0)	0.9	0-7	8 (87.5)	8 (25.0)
Haplospiza unicolor	11 (9.1)	0.6	0-7	7 (85.7)	7 (28.6)
Amaurospiza moesta	3 (66.6)	2.0	0-4	1 (100)	1 (0)
Saltator similis	1 (0)	0.0	0	-	-
TOTAL (53)	311 (45.7)	2.3	0-57	150 (88.7)	150 (66.7)