

- POST, W., A. CRUZ AND D. D. MCNAIR. 1993. The North American invasion pattern of the Shiny Cowbird. *J. Field Ornithol.* 64:32-41.
- POST, W., AND J. W. WILEY. 1977. The Shiny Cowbird in the West Indies. *Condor* 79:176-184.
- WEST, M. J., A. P. KING, D. H. EASTZER, AND J. E. R. STADDON. 1979. A bioassay of isolate cowbird song. *J. Comp. Physiol. Psychol.* 93:124-133.
- WILEY, J. W. 1985. Shiny Cowbird parasitism in two avian communities in Puerto Rico. *Condor* 87: 165-176.

Received 6 September 1994, accepted 20 June 1995.

The Auk 112(4):1041-1043, 1995

High Prevalence of Hematozoa in Nestlings of a Passerine Species, the Pied Flycatcher (*Ficedula hypoleuca*)

SANTIAGO MERINO AND JAIME POTTI

Departamento de Biología Animal, Universidad de Alcalá de Henares, E-28871 Madrid, Spain

For birds in general, there is a dearth of data on prevalence and intensity of blood parasites in nestlings. This may be due to the fact that researchers have not expected to find blood parasites in smears because of the short time for infections to be detected. While this may be true in many passerines, mainly ground-nesting species with short fledgling periods, we show here that prevalences may be detected as early as 13 days of age in a cavity-nesting passerine. Prevalences and intensities of hematozoa in nestling birds may merit further study, as both parameters are relatively easy to quantify in smears of peripheral blood in bird species such as the Pied Flycatcher (*Ficedula hypoleuca*, Muscipapidae), which has a relatively extended fledgling period.

In 1993, an intensively studied population of Pied Flycatchers in central Spain (Potti 1993) was sampled for presence of hematozoa. Adult birds were captured while incubating (females) or feeding nestling (males); a drop of blood was obtained from the brachial vein, smeared, air dried, and fixed with 100% ethanol. Slides were later stained with Giemsa for 45 min. In addition, one nestling per nest was picked at random and bled at 13 days of age. We chose this age because it is the standard age of banding and measuring fledglings that are fully grown with respect to some skeletal measures (Potti and Merino 1994) in our population, and not by any consideration on the prepatent periods of hematozoa.

To prevent the possibility that the symmetry of the blood smear might cause a nonrandom distribution of parasites (Godfray et al. 1987), one-half a smear (i.e. the half being chosen at random) was entirely scanned at 200 \times along its longitudinal axis for presence of *Trypanosoma* spp. and *Leucocytozoon* spp. We quantified the number of these hematozoans by counting the number of fields scanned and transforming parasite numbers to parasites per 100 fields. Infection by *Haemoproteus balmoralis* was detected and quantified

under oil at 1,000 \times by counting the number of parasites per 2,000 erythrocytes (Godfray et al. 1987) in the other half of the smear (i.e. that not scanned at 200 \times).

The prevalences and intensities of infection by different genera of hematozoa in nestlings and both sexes of adult breeding birds are shown in Table 1. The fact that no *Haemoproteus* was observed in nestlings is probably due to the length of the prepatent period for these parasites which is about 14 days (Fallis and Bennett 1961). The two other genera of parasites present in nestlings have prepatent periods of about five days (Fallis and Bennett 1961, Molyneux 1973; but see Baker 1956b); hence, the nestlings should have been infected early in life, at least at the age of seven to eight days. In this population there are several species of ectoparasites that potentially may act as vectors of hematozoa (Merino and Potti 1995, in press). For example, mites (Acari) of the genus *Dermanyssus* are common nest parasites in this population of Pied Flycatchers, and have been reported as vectors of trypanosomes (Macfie and Thomson 1929). Hosts may become infected with these parasites by swallowing vectors (Baker 1956a, Dirie et al. 1990), or by the vector's faeces containing infective stages penetrating the hosts through scars (Molyneux 1977). It would appear that *Trypanosoma* infections acquired during the fledgling period may be maintained until adulthood, as prevalences are similar in both age classes in a horizontal analysis of young and adult birds ($X^2 = 0.00$, $P = 1.00$, Yates' correction). However, this assumes between-age variation also reflects within-bird variation of parasite prevalence with age, which remains to be demonstrated until effects on recruitment (i.e. postfledgling mortality) are ascertained.

The intensity of infection by trypanosomes in nestlings is four times higher than in adult birds (Table 2; Mann-Whitney test comparing nestlings vs. adult

TABLE 1. Number (with percentage in parentheses) of birds infected by different genera of hematozoa among adult and nestling Pied Flycatchers. Numbers of birds infected with any hemoparasite shown under column labelled Total infected.

Host	<i>n</i>	<i>Trypanosoma</i>	<i>Leucocytozoon</i>	<i>Haemoproteus</i>	Total infected
Nestling	96	20 (20.83)	1 (1.04)	0 (0.00)	20 (20.83)
Male	99	17 (17.17)	1 (1.01)	11 (11.11)	25 (25.25)
Female	111	26 (23.42)	1 (0.90)	22 (19.82)	43 (38.74)

birds, $Z = 4.04$, $P < 0.001$), most likely due to a poorly developed immune system in young birds (Olson 1974, Cheng 1976), although it could be also due to higher exposure of young to nest ectoparasites. However, if parasitemias were only related to inoculation rate (infection within nest by mites or other vectors), the females tending the young would be similarly parasitized. That this was not the case seems to reinforce the idea that the adult immune system plays a major role in controlling the infection. However, there was no relationship between prevalences of *Trypanosoma* among fledglings sampled for hematozoa and their parents (Fisher's exact probability test, $P > 0.90$ for both).

Only two published studies report prevalence of hematozoa in nestling passerines, one of which concerns nestling Pied Flycatchers surveyed for hematozoa by Bennett et al. (1974). They examined 47 individuals, all of which were free of observable hematozoa. The other study is that of Weatherhead and Bennett (1991), who reported the infection by *Plasmodium polare* in 1 of 119 nestlings of Red-winged Blackbirds (*Agelaius phoeniceus*) examined for hematozoa at the age of 11 days. We found relatively high prevalences of trypanosomes in the Pied Flycatcher, around 20%. Furthermore, our estimates may be conservative, as inspection of *Trypanosoma* in smears is not the most accurate technique to detect infection (Bennett 1962, Apanius 1991). However, our results point out that early infection can occur, and it may be detected in smears at early ages. Hence, the survey of nestlings for hematozoa may be worthwhile, especially in altricial birds with relatively long fledgling periods (i.e. longer than hematozoan prepatent periods), such as those of birds of prey (Dirie et al. 1990), ciconiiforms (Telford et al. 1992, Prigioni and Sacchi 1993), and cavity-nesting bird species. However, this should not imply that heritability of sus-

ceptibility or resistance to blood parasites may be readily estimated with this type of data (Weatherhead and Bennett 1991), as resistance to parasites may be acquired only after exposure to them (Isobe et al. 1993). Therefore, longitudinal data from recruiting birds will be necessary to examine familiar resemblance in blood parasite loads and prevalences (Weatherhead and Bennett 1991), even in the case where both can be assessed at the nestling stage. These data may also throw light on the roles that these parasites may have on the growth and survival of young birds.

Acknowledgments.—Our work was funded by the Spanish CICYT (Comisión Interministerial de Ciencia y Tecnología; project PB91-0084-C03-03).

LITERATURE CITED

- APANIUS, V. 1991. Avian trypanosomes as models of hemoflagellate evolution. *Parasitol. Today* 7:87-90.
- BAKER, J. R. 1956a. Studies on *Trypanosoma avium* Danilewsky 1885. II. Transmission by *Ornithomyia avicularia* L. *Parasitology* 46:321-334.
- BAKER, J. R. 1956b. Studies on *Trypanosoma avium* Danilewsky 1885. III. Life cycle in vertebrate and invertebrate hosts. *Parasitology* 46:335-352.
- BENNETT, G. F. 1962. The haematocrit centrifuge for laboratory diagnosis of hematozoa. *Can. J. Zool.* 40:124-125.
- BENNETT, G. F., C. J. MEAD, AND S. F. BARNETT. 1974. Blood parasites of birds handled for ringing in England and Wales. *Ibis* 117:232-235.
- CHENG, T. C. 1976. *General parasitology*. Academic Press, New York.
- DIRIE, M. F., R. W. ASHFORD, L. M. MUNGOMBA, D. H. MOLYNEUX, AND E. E. GREEN. 1990. Avian trypanosomes in *Simulium* and Sparrowhawks (*Accipiter nisus*). *Parasitology* 101:243-247.
- FALLIS, A. M., AND G. F. BENNETT. 1961. Sporogony of *Leucocytozoon* and *Haemoproteus* in simuliids and ceratopogonids and a revised classification of the Haemosporidiida. *Can. J. Zool.* 39:215-228.
- GODFRAY, R. D., A. M. FEDYNICH, AND D. B. PENCE 1987. Quantification of hematozoa in blood smears. *J. Wildl. Dis.* 23:558-565.
- ISOBE, T., S. YOSHIHARA, AND K. SHIMURA. 1993. Resistance of chicks against reinfection with *Leucocytozoon caulleryi*. *Avian Dis.* 37:27-30.

TABLE 2. Mean intensity of infection (sensu Margolis et al. 1982) by trypanosomes in nestling and adult Pied Flycatchers of both sexes.

Host	<i>n</i>	$\bar{x} \pm SD$ (range)
Nestling	20	4.55 \pm 4.92 (0.33-15.90)
Male	17	0.96 \pm 1.04 (0.19-3.54)
Female	26	1.34 \pm 2.13 (0.29-10.99)

- MACFIE, J. W. S., AND J. G. THOMSON. 1929. A trypanosome of the canary (*Serinus canarius* Koch). *Trans. R. Soc. Trop. Med. Hyg.* 14:231-234.
- MARGOLIS, L., G. W. ESCH, J. C. HOLMES, A. N. KURIS, AND G. A. SCHAD. 1982. The use of ecological terms in parasitology (report of an ad hoc committee of the American Society of Parasitologists). *J. Parasitol.* 68:131-133.
- MERINO, S., AND J. POTTI. 1995. Mites and blowflies decrease growth and survival in nestling Pied Flycatchers. *Oikos* 73:95-103.
- MERINO, S., AND J. POTTI. In press. Weather dependent effects of nest ectoparasites on their bird hosts. *Ecography*.
- MOLYNEUX, D. H. 1973. *Trypanosoma bouffardi* of West African Ploceidae (Aves). *Parasitology* 66:215-230.
- MOLYNEUX, D. H. 1977. Vector relationships in the Trypanosomatidae. *Adv. Parasitol.* 15:1-82.
- OLSEN, O. W. 1974. *Animal parasites*. University Park Press, Baltimore.
- POTTI, J. 1993. Environmental, ontogenetic, and genetic variation in egg size of Pied Flycatchers. *Can. J. Zool.* 71:1534-1542.
- POTTI, J., AND S. MERINO. 1994. Heritability estimates and maternal effects on tarsus length in Pied Flycatchers, *Ficedula hypoleuca*. *Oecologia* 100:331-338.
- PRIGIONI, C., AND L. SACCHI. 1993. Factors affecting the prevalence of *Leucocytozoon* in Italian Ardeidae. *Boll. Zool.* 60:81-85.
- TELFORD, S. R., JR., M. G. SPALDING, AND D. J. FORRESTER. 1992. Hemoparasites of wading birds (Ciconiiformes) in Florida. *Can. J. Zool.* 70:1397-1408.
- WEATHERHEAD, P. J., AND G. F. BENNETT. 1991. Ecology of Red-winged Blackbird parasitism by haematzoa. *Can. J. Zool.* 69:2352-2359.

Received 19 September 1994, accepted 8 March 1995.

The Auk 112(4):1043-1045, 1995

Use of Fluorescent Powder for Tracking American Woodcock Broods

ANN K. STEKETEE¹ AND WILLIAM L. ROBINSON

Department of Biology, Northern Michigan University, Marquette, Michigan 49855, USA

In recent decades movements of many species have been described through the use of radio-telemetry (see White and Garrott 1990). Radio-telemetry permits monitoring of animal activities on a daily or more frequent basis, but has several limitations. For example, radio transmitters are expensive and their use is limited by the size of the animal and its ability to carry a transmitter. Since locations are estimated by triangulation, accuracy varies with distance from transmitter to receiver, topography, and density of vegetation (Mech 1983). Triangulation of radio-marked individuals is only accurate to within a few meters and telemetry provides no information on the route used between two locations (Lemen and Freeman 1985).

Transmitters were not useful for tracking the movements of American Woodcock (*Scolopax minor*) chicks that were less than seven days old or had a mass of less than 40 g (Horton and Causey 1981). Some hens with chicks less than four days old abandoned their broods when radio-tagged (Horton and Causey 1984).

Thus, information about the movements of woodcock chicks was inferred from tracking radio-marked hens.

Fluorescent powder has been used to track small mammals and has yielded accurate information on the location of animals, enabling researchers to trace the exact movements of individuals on trails as long as 900 m (Lemen and Freeman 1985, Kaufman 1989). However, few researchers have used fluorescent powder on birds. There was no published literature on the use of this technique with birds of any type when this study was begun. We report results of the use of fluorescent powder to describe the movements and brood coherence of American Woodcock chicks.

Methods.—Research was conducted in and around the Gene's Pond Study Area (GPSA), Dickinson County, in the Upper Peninsula of Michigan (46°N, 88°W). The area encompasses approximately 9 km² and is covered by mixed forests with numerous clear-cuts of various ages regenerating to aspens (*Populus* spp.).

Woodcock chicks were located in May and June of 1992 and 1993 using flushing and pointing dogs, and captured by hand or in hand-held nets (as described by Ammann 1981). Chicks were banded with U.S. Fish and Wildlife Service metal leg bands, aged to the day by bill length (Ammann 1982), and weighed. About 1 cc of fluorescent powder (Radiant Color, Richmond, California) was applied to the legs and abdomen of a chick by shaking the powder from a

¹ Current address: West Virginia Cooperative Fish and Wildlife Research Unit, 333 Percival Hall, West Virginia University, Morgantown, West Virginia 26505, USA.