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 haematozoa. 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. STEKETEE[1] 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 km^2 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.

salt shaker and rubbing it into the down feathers by hand, saturating the down with powder. Each chick received one of three available colors: red, orange or chartreuse. If four chicks were present, the fourth was either left unmarked or given red powder, because this color seemed to be the easiest to track. Chicks were released together at the capture site, and researchers immediately left the area to allow the hen to return and tend the chicks.

Tracking was done after dark on the evening following the application of powder. A portable ultraviolet light was used to follow powder trails left as chicks brushed against vegetation. The intensity of a trail varied from a few powder grains to smears 5 cm long. We found that a trail remained detectable for 24 to 48 h after application or until a heavy rain. We marked each trail with slender colored stakes, every 15 to 60 cm or every time the chick appeared to change directions. The following day, distance and azimuth between successive stakes were measured, and a map of each chick's movements drawn from this information. The occurrences of protective cover, vegetation types, and inhibiting obstacles were recorded and mapped. Maps were drawn on grid paper using a compass and ruler. This information was then digitized into a computer and a final map made.

To determine how long powder remained on downy chicks, we applied powder to 12 two-day-old, marked domestic chickens (*Gallus gallus*) using the same method as for woodcock chicks. Six chicks received powder on the legs and abdomen and six chicks did not. All 12 were kept together and brooded by a single hen. The amount of powder retained on the chicks was observed over the next several days until no evidence of the powder remained.

Results and discussion.—Powder was applied to 31 Woodcock chicks from 12 broods. Chicks ranged in age from 1 to 17 days with a mean age of 6.6 days. Trails of nine broods were followed within 26 h of capture. In five cases, the trail led directly to the chicks and hen, whereas the remaining trails ended at apparent overnight brood sites. Overnight brood sites were identified by the presence of all three colors in a circle of about 15 cm, or by the presence of the chicks and hen. Powder deposits at overnight brood sites often were dense enough to be visible in sunlight the following day. Day brooding sites also were identified by the presence of all three colors, but such sites had less dense deposits of powder and clear (with the blacklight) trails leading away from them.

The lengths of trails varied from 24 to 303 m and averaged 106 m. The shortest trail was made by two six-day-old chicks that traveled 24 m in approximately 1.5 h, whereas, the longest trail was made by a brood of three 13.5 day old chicks which traveled 132 m in 8 h. The latter brood was repowdered and tracked again the following evening for an additional 170 m.

Hourly movement rates were estimated using time from release to 0.5 h after sunset, when nocturnal brooding of chicks apparently begins. Movement rates varied from 7.7 to 29.1 m/h, with an average rate of 15.5 m/h. The correlation between brood age and rate of travel was not statistically significant ($r = 0.52$, $n = 9$). Other researchers tracking radio-marked hens to determine brood movement rates reported flightless broods moving 16.8 ± SD of 20.4 m/h (Bruggink 1987), and 18 to 27 m/h (Wenstrum 1973). However, Mendall and Aldous (1943) reported a day-old brood covering 22.9 m of "exceedingly dense" cover in 20 min, which extrapolates to 68.6 m/h.

Brood cohesiveness was difficult to determine because of problems in distinguishing individual chicks given the same color. "Minimum-maximum" distances were determined by measuring the distance between the most widely separated trails of chicks. Because we could not tell whether the chicks were in these positions simultaneously, these estimates represent the shortest possible maximum distance. Distances ranged from 0 to 157 cm and averaged 73 ± 44 cm. Cohesiveness was not correlated with brood age ($r = 0.47$, $n = 9$). Such short separation distances suggest that, upon approach by a potential predator, chicks tend to scatter more than they do during their normal travels. Frequently, chicks would be separated from each other by a few meters when encountered by researchers after flushing a hen.

Chicks apparently were not hindered by obstacles such as slash piles, fallen logs, and roads. One brood proceeded over a discarded automobile tire about 20 cm tall and 63 cm wide. A brood of four one-day-old chicks successfully crossed a slash pile, which was 10.9 m across and 1.1 m tall; it included a 0.7-m free-fall.

On the domestic chickens, powder was still detectable 36 h after application, but they were no longer leaving a trail. Only faint traces of the powder remained in the plumage after 72 h. The hen and unmarked chicks were slightly contaminated by powder from marked chicks, but did not leave a visible trail. Also powder did not remain as long on the plumage of hens. All powdered chickens survived to 14 weeks old with no apparent ill effects.

Five of 31 woodcock chicks marked with powder in 1992 and 1993 were recaptured in mist nets later in the summer, a recovery rate of 16.1%. The recapture rates of nonpowdered, hatch-year woodcocks on the GPSA during 1992-1993 was 13.8% (10 of 72). This difference in recapture rates between powdered and unpowdered woodcock chicks was not significant ($z = 0.30$, $P > 0.05$), suggesting that the powder did not affect survival.

The use of fluorescent powder provided accurate information on distance moved, habitat used, distance between foraging or traveling brood members, and exact routes followed, as well as brood relocation. Fluorescent powder can be used on chicks too small to carry radio transmitters. It has the further advantage of being relatively inexpensive, and it is reported

to have low toxicity (manufacturer's Materials Safety Data Sheet). The powder has no detectable odor to humans. The trail to the first overnight brood site can be followed up to three days after marking and is not affected by light rain or dew. If the brood is to be recaptured, however, the trail must be followed the night of the original capture, given that the trail away from the overnight brood site tends to be less obvious and harder to follow.

There are several potential drawbacks to using the fluorescent powder. This method does not permit actual location-time distributions or speed of movement, and probably is ineffective with flying members of broods. Monitoring a broods movements over several days or weeks is not possible without reapplying powder. Finally, powder may make chicks vulnerable to predation by altering their cryptic coloration; however, restricting powder to the ventral area minimizes its visibility. Despite these disadvantages, powder tracking has potential for tracing movements of a variety of precocial, terrestrial bird chicks, including quail and pheasants (Phasianinae), grouse (Tetraoninae), and Wild Turkeys (*Meleagris gallopavo*).

Acknowledgments.—We thank J. C. Steketee and B. J. Dudek for capable field assistance, M. Halley and "Zeke" for help in locating broods, J. P. Farrell for cartography, G. Griffith for reviewing the Materials Safety Data Sheet, J. Knight for equipment repairs, and P. M. Wagner for typing the manuscript. Financial support has been provided by the Ruffed Grouse Society, the Peter White Fellowship Fund of Northern Michigan University, T. Spanos, G. Burroughs, and C. Williams.

LITERATURE CITED

AMMANN, G. A. 1981. A guide to capturing and banding American Woodcock using pointing dogs. Ruffed Grouse Society, Coraopolis, Pennsylvania.

AMMANN, G. A. 1982. Age determination of American Woodcock chicks by bill length. Pages 22–25 *in* Woodcock ecology and management (T. J. Dwyer and G. L. Storm, Technical Coordinators). U.S. Fish Wildl. Serv., Wildl. Res. Rep. 14.

BRUGGINK, J. G. 1987. Local movements, diurnal home range size, and habitat characteristics of woodcock in the Upper Peninsula of Michigan. M.A. thesis, Northern Michigan Univ., Marquette.

HORTON, G. I., AND M. K. CAUSEY. 1981. Woodcock movement and habitat utilization in central Alabama. J. Wildl. Manage. 43:414–419.

HORTON, G. I., AND M. K. CAUSEY. 1984. Brood abandonment by radio-tagged American Woodcock hens. J. Wildl. Manage. 48:606–607.

KAUFMAN, G. A. 1989. Use of fluorescent pigments to study social interactions in a small nocturnal rodent, *Peromyscus maniculatus*. J. Mammal. 70:171–174.

LEMEN, C. A., AND P. W. FREEMAN. 1985. Tracking mammals with fluorescent pigments: A new technique. J. Mammal. 66:134–136.

MECH, L. D. 1983. Handbook of animal radio-tracking. Univ. Minnesota Press, Minneapolis.

MENDALL, H. L., AND C. M. ALDOUS. 1943. The ecology and management of the American Woodcock. Maine Cooperative Fish and Wildlife Research Unit, Univ. Maine, Orono.

WENSTROM, W. P. 1973. Habitat utilization and activities of female American Woodcock (*Philohela minor* Gmelin) in northeastern Minnesota during spring and summer. Ph.D. thesis, Univ. Minnesota, St. Paul.

WHITE, G. C., AND R. A. GARROTT. 1990. Analysis of wildlife radio-tracking data. Academic Press, San Diego.

Received 14 March 1994, accepted 5 September 1994.

The Auk 112(4):1045–1049, 1995

Lack of Restriction-site Variation in Mitochondrial-DNA Control Region of Whooping Cranes (*Grus americana*)

SHERI A. SNOWBANK[1] AND CAREY KRAJEWSKI
Department of Zoology, Southern Illinois University, Carbondale, Illinois 62901, USA

In 1941 the number of living Whooping Cranes (*Grus americana*) dwindled to just 15 individuals (Binkly and Miller 1983). However, as a result of conservation efforts over the past 50 years, there are presently 164 birds in the wild and another 159 in captivity (C. Mirande pers comm.). This recovery is dramatic because gruine cranes are long-generation-time species (12 years) with low annual fecundity (rarely more than one fledgeling per year). Despite captive breeding and other conservation programs, concerns about Whooping Crane survival persist. Not least of

[1] Present address: 392 29½ Avenue, Barronett, Wisconsin 54813, USA.