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Flight speeds of birds determined using Doppler radar.—We determined ground speeds of 12 species of birds (Table 1) in Jackson and Williamson counties in southern Illinois during the first two weeks of May 1991 using a Model K-15 Traffic Radar Unit (M.P.H. Industries, Chanute, Kansas). The unit has an internal calibration mechanism capable of maintaining and checking the accuracy of the digital circuitry. A tuning fork certified to oscillate at 1561 Hz was used for external calibration.

The objectives of our study were to (1) describe the correction factors required in using hand-held Doppler radar when obtaining flight speeds, (2) obtain measurements of non-migratory flight speeds of birds engaged in similar activities during the breeding season, and (3) relate these flight speeds to time of day, diet, foraging type, and roost type.

The K-15 Traffic Radar Unit uses a solid state Gunn Oscillator that generates radio energy in the microwave region. This energy is focused into a narrow beam and directed at the target at the speed of light. A portion of the beam is reflected back to the transmitter where a solid state mixer diode compares the frequency of the reflected beam to the transmitted frequency. The difference between the two frequencies is the Doppler frequency. The electronic circuitry then converts the Doppler frequency into a digital presentation of the target's speed.

Radar units are calibrated for direct line measurement of the speed of the target. If the target object approaches or recedes at an angle (this may involve deviations of azimuth, declination, or both), a portion of the motion will not be measured and recorded flight speed will be less than true speed. The magnitude of error increases as deviation(s) of azimuth and/or declination angle(s) increase.

The angle of azimuth (A) of the bird's flight path was determined with angles delineated on top of the radar unit. We discarded flight speeds of birds flying at an angle of greater than 10° either side of center. Angles of less than 10° produce less than a 1% error. To measure the angle of declination (B) we mounted a protractor on the side of the radar unit with a plumb line hanging from the center of the protractor. As the speed was recorded, the

TABLE 1
FLIGHT SPEEDS (M/SEC) OF BIRDS DURING DAYTIME AND EVENING

Species	Midday		Evening	
	N	Mean ± SE	N	Mean ± SE
Mourning Dove (*Zenaida macroura*)	7	9.88 ± 0.37	10	11.97 ± 0.75
Chimney Swift (*Chaetura pelagica*)	6	10.33 ± 0.50	10	12.26 ± 0.73
Purple Martin (*Progne subis*)	7	8.45 ± 0.41	8	11.09 ± 0.94
Cliff Swallow (*Hirundo pyrrhonota*)	9	9.83 ± 0.48	6	8.74 ± 0.50
Tree Swallow (*Tachycineta bicolor*)	9	10.02 ± 0.47	6	9.22 ± 0.57
Northern Mockingbird (*Mimus polyglottos*)	7	10.01 ± 0.21	4	9.30 ± 0.31
American Robin (*Turdus migratorius*)	8	7.22 ± 0.31	7	10.36 ± 0.75
Red-winged Blackbird (*Agelaius phoeniceus*)	5	10.02 ± 0.82	10	11.30 ± 0.75
Commnn Grackle (*Quiscalus quiscula*)	6	10.18 ± 0.16	9	11.71 ± 0.61
Eastern Meadowlark (*Sturnella magna*)	10	8.35 ± 0.31	5	12.02 ± 0.66
European Starling (*Sturnus vulgaris*)	7	9.95 ± 0.40	7	12.74 ± 0.86
House Sparrow (*Passer domesticus*)	10	10.21 ± 1.12	5	12.31 ± 1.10

line was pulled taut against the protractor and the angle was recorded along with registered speed. Values in m/sec were corrected for the angle of the bird's flight path relative to the radar unit's beam using the formula:

$$\text{Ground speed} = \text{recorded speed} \times 1/\cos(A) \times 1/\cos(B).$$

Measurements were obtained during two time periods: from 11:00 to 14:00 h CDST (midday period) and from 18:00 to 20:00 h CDST (evening period). We recorded 4–10 different birds for each species at each daily time period. All measurements were made on birds not in a state of alarm, flying at a distance of 10–60 m from the observer, and flying not over 20 m above the ground.

A two-way analysis of variance using the SAS GLM procedure (SAS Institute 1989) revealed significant species differences ($F = 4.40$; df $= 11,154$); $P < 0.001$), significant time period differences ($F = 29.24$; df $= 1,154$; $P < 0.001$), and a significant interaction term ($F = 2.52$; df $= 11,154$; $P < 0.01$). A Tukey/Kramer multiple-comparison procedure (Hinkle et al. 1988) revealed that, with the two time periods combined, Chimney Swifts and European Starlings (see Table 1 for scientific names) flew significantly faster than American Robins; measured flight speeds of the other species were not significantly different from one another. For four species measured (Purple Martins, American Robins, Eastern Meadowlarks, and European Starlings), ground speeds were significantly faster in the evening than at midday. While not statistically significant, measured speeds of three species (Cliff Swallows, Tree Swallows, and Northern Mockingbirds) were higher at midday than evening; these patterns of interspecific variation account for the significant interaction term. We also examined flight speed variation with regard to main diet (frugivore, aerial insectivore, and terrestrial insectivore), roost type (colonial, communal, and territorial), and style of flight (flapping and combination flap-glide). No statistically significant differences were found for any of these categories.

Ground speeds for the 12 species in this study showed considerable variability as indicated by the SE values. Schnell (1965, 1974), Tucker and Schmidt-Koenig (1971), Schnell and Hellack (1978, 1979), and McLaughlin and Montgomerie (1990) also report high variability in measured ground speeds. Flying at minimum power velocity (Vmp) or maximum range velocity (Vmr) may be of less importance to birds flying at or near the nest area with abundant resources, than to birds on migration.

Non-migratory flight speed is determined by behavioral activities of birds and delimited by morphologic, physiologic, and aerodynamic constraints. Determination of flight speeds of birds in their daily habitat is necessary for closer examination of energetic costs of flight.

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Song variation within and among populations of Red-winged Blackbirds.—Evolution of micro-geographic song variation (e.g., dialects) and sizes of song repertoires continues to be a major interest, and comparative data from different populations of widespread species can help us understand the forces that produce such song variation. Because Simmers (1975) found no obvious differences in song of Red-winged Blackbirds (*Agelaius phoeniceus*) among New England sites, and because differences in song form and repertoire size are not substantial among northern, mostly migratory populations (e.g., Smith and Reid 1979, Yasukawa et al. 1980, Yasukawa 1981, Brenowitz 1983), we tested whether vocal behavior in two more southern and perhaps more sedentary populations, one in Florida and one in California, differed from northern populations.

Methods.—We recorded Red-winged Blackbirds at several sites. Our most intensive efforts were at Carr Lake, near Tallahassee, Florida, 22–29 April 1987. Most males had been banded with distinctive combinations of colored and aluminum bands. One male (male 17; see