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Received 21 April 1993, accepted 28 July 1993.

Wilson Bull., 106(1), 1994, pp. 150–154

Correlation between raptor and songbird numbers at a migratory stopover site.—Certain landscape features, such as coastlines, often concentrate raptors during their migration (Mueller and Berger 1967, Dunne and Clark 1977, Bednarz et al. 1990). A number of falconiform species that cross the Gulf of Mexico during both the spring and fall migrations have been seen on the barrier islands that parallel the northern Gulf of Mexico (Moore et al. 1990). These islands are important stopover areas for migrating songbirds (Moore and Kerlinger 1987) because they represent their first opportunity to rest and replenish depleted fat stores following trans-Gulf flight. The islands may also be important for migrating hawks by virtue of the concentration of songbird migrants (Kerlinger 1989). Passerine migrants are an important resource for raptors during migration, and migrating raptors have been observed hunting at stopover sites (Hunt and Ward 1988, Lindström 1989, Moore et al. 1990).

I examined the co-occurrence of raptors and songbirds during migration by observing the passage and behavior of raptors at a migratory stopover site. The work was conducted on East Ship Island (ESI), a barrier island which lies approximately 19 km from the Mississippi coast (see Kuenzi et al. 1991), between 2 April and 6 May 1991. Although the focus of research on the island was the stopover ecology of songbirds, I and three field assistants noted the presence and behavior of raptors throughout the daylight hours. We identified the species, whether or not it was flying (an indicator of predatory activity), any attacks on migrants, and evidence of feeding on migrants. Some individual raptors may have been counted more than once as the raptors were not marked.

We counted 50 Merlin (*Falco columbarius*) and 55 Peregrine Falcon (*F. peregrinus*) observations. Five American Kestrels (*F. sparverius*) and three Swallow-tailed Kites (*Elanoides forficatus*) were also seen, but their numbers do not permit statistical analysis. Falcon sight-

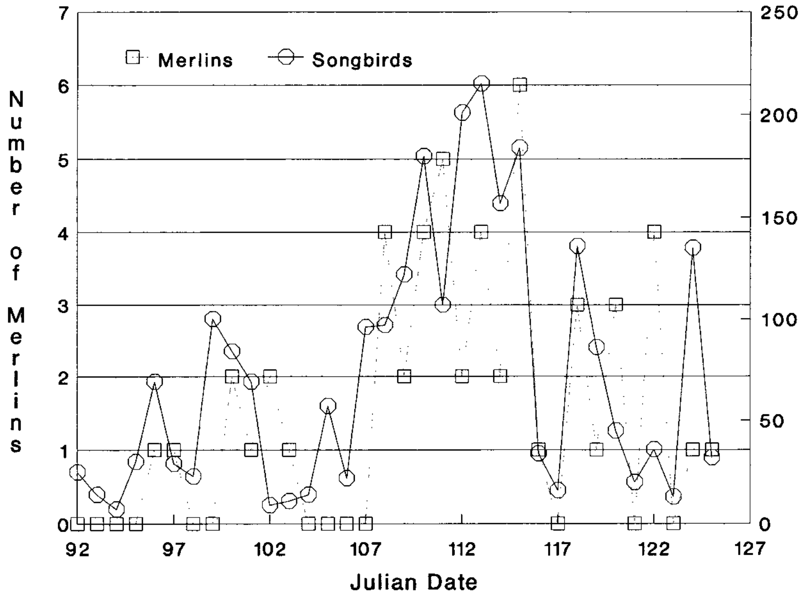

FIG. 1. Passage of Merlins and songbirds, E. Ship Island, 1991.

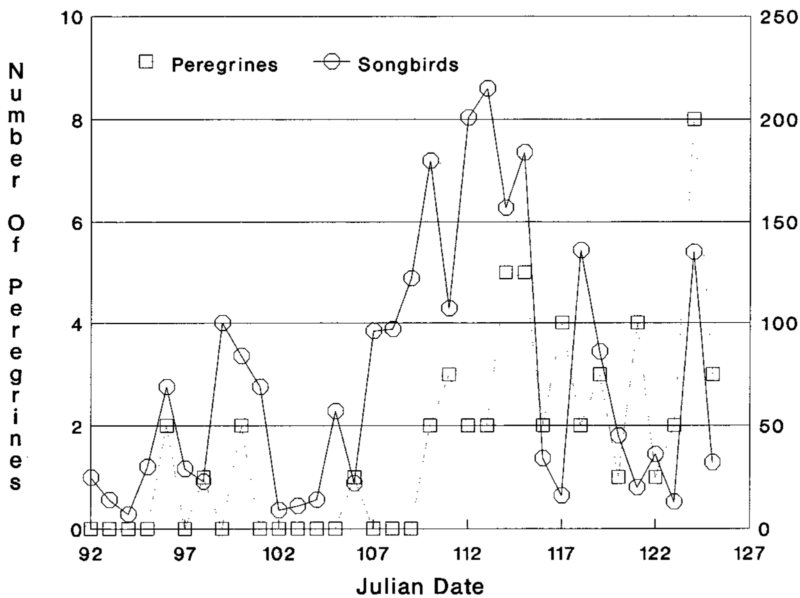

FIG. 2. Passage of Peregrine Falcons and songbirds, E. Ship Island, 1991.

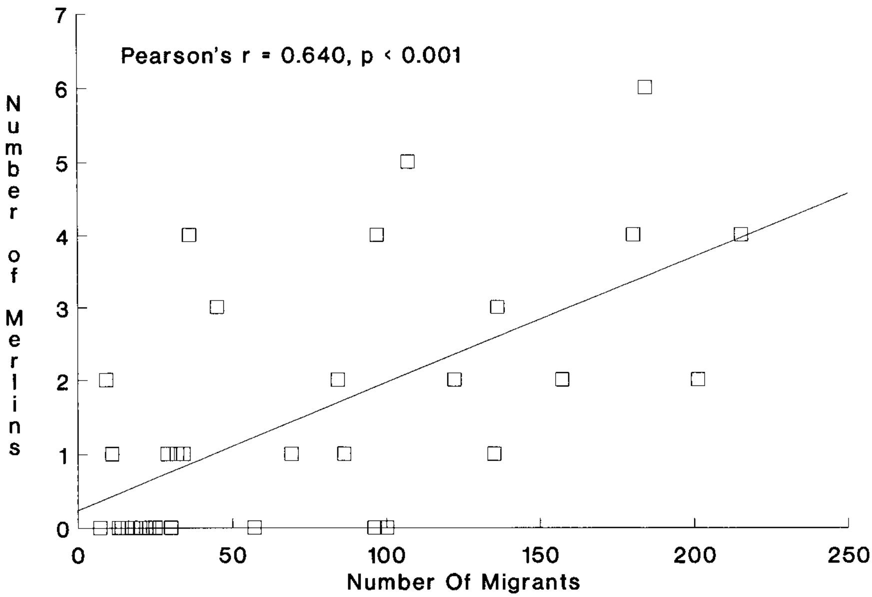

FIG. 3. Correlation between Merlin and songbird numbers, E. Ship Island, 1991.

ings coincided with the number of songbirds caught in mist-nets (Figs. 1 and 2). Pearson correlation analyses indicate that both Merlin and Peregrine Falcon numbers were correlated significantly with migrant numbers (Figs. 3 and 4). The coincidental timing of raptor migration with songbird migration could be explained by two hypotheses. First, hawks may be tracking a resource which is important to their survival during migration. Kerlinger (1989) has speculated that hawks may migrate along coastlines to take advantage of easily captured, energetically stressed prey. Raptors captured songbird migrants on East Ship Island: 14% of Merlins and 6% of Peregrine Falcons were seen attacking prey, and 8% of Merlins were seen with recently killed prey. Second, weather conditions that are favorable to songbird migration also are favorable for raptor migration. The correlation between Merlin and Peregrine Falcon numbers and songbird numbers on East Ship Island may also stem from a similar response to prevailing weather conditions. Both songbird migrants and Merlins take advantage of following winds when making water crossings (e.g., Nisbet 1970, Kerlinger 1989; see also Gauthreaux and Able 1970). The same headwinds or rain that force songbird migrants to "fallout" following trans-Gulf passage (Moore and Kerlinger 1987) may concentrate Merlin in the barrier islands along the northern coast of the Gulf of Mexico. Being stronger fliers, Peregrine Falcons may not be forced to land unless winds or storms are especially strong. This might explain why Peregrine Falcon sightings did not increase until the second half of the season (Fig. 2), whereas Merlin sightings were more evenly distributed (Fig. 1). It is also possible that the pattern observed for Peregrine Falcons is their typical timing of migration through this area.

Predation pressure is one of the many risks songbirds face during their annual migration, which must be balanced against their need to meet energetic demands. The Gulf coast barrier islands are important in helping songbirds to satisfy their energetic requirements, and in so doing, provide a resource for migrating raptors to do the same. The increase in predation

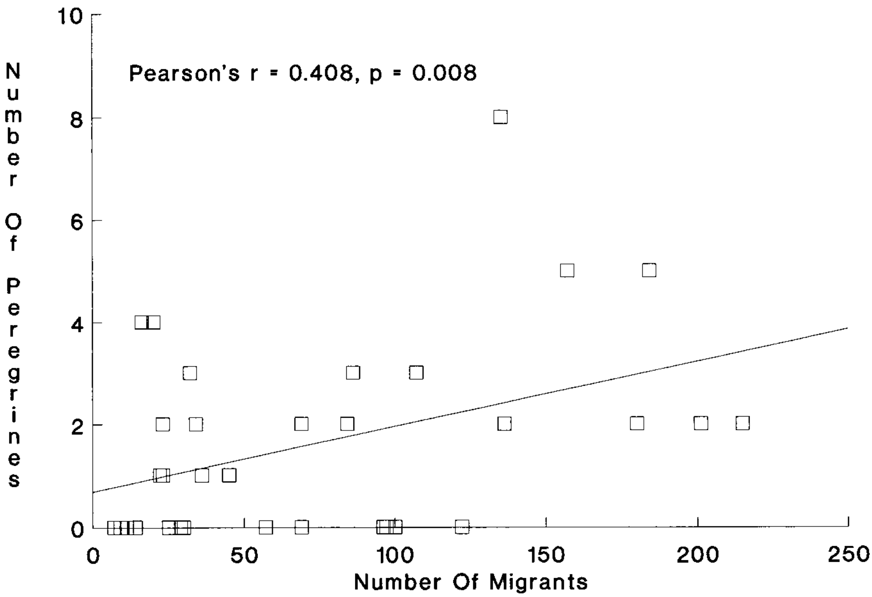

FIG. 4. Correlation between Peregrine Falcon and songbird numbers, E. Ship Island, 1991.

pressure may affect the foraging behavior and habitat use of songbird migrants, possibly delaying their arrival on the breeding or wintering grounds. Further investigations of raptor migration at stopover locations would prove valuable in understanding the relationship between songbirds and raptors during migration.

Acknowledgments.—I thank Jeff Clark, John Simon, and Wang Yong for help in the collection of data. Paul Kerlinger, Frank Moore, Jill Busby, David Cimprich, Jeff Clark, Roland Sandberg, Mark Woodrey, and Wang Yong made helpful comments on earlier drafts of the manuscript. Research on the stopover ecology of landbird migrants is supported by NSF grants BSR-9020530 and BSR-9100054 to F. Moore.

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Wilson Bull., 106(1), 1994, pp. 155–156

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