# RAPTOR AND WADING BIRD MIGRATION IN VERACRUZ, MEXICO: SPATIAL AND TEMPORAL DYNAMICS, FLIGHT PERFORMANCE, AND MONITORING APPLICATIONS

Ernesto Ruelas Inzunza

Dr. John Faaborg, Dissertation Advisor

## ABSTRACT

This dissertation is organized in four chapters that deal with different aspects of my long-term studies of migratory raptors, vultures, and wading birds, in central Veracruz, Mexico, during the course of three spring and ten fall seasons (1991-2004). The first chapter is a descriptive piece with a discussion of the role of regional topography and altitudinal distribution of thermal convection in the formation of a geographic bottleneck for soaring migrants.

I examine several characteristics (such as flocking behavior and flight mode) of an assemblage of migratory birds composed of 33 species of nine families in order to understand why these birds are funneled through this area. I also describe the magnitude of these migrations, their inter-annual variation, flocking behavior, and flight mode, and briefly discuss issues related to their stopover ecology and conservation.

One of the outstanding findings of this project is documenting the migration of over 0.8 million birds in spring and over 5.1 million in fall, the most important migratory flyway for raptors in the World. These migrations are dominated by seven species:

American White Pelican (*Pelecanus erythrorhynchos*), Anhinga (*Anhinga anhinga*), Wood Stork (*Mycteria americana*), Turkey Vulture (*Cathartes aura*), Mississippi Kite (*Ictinia mississippiensis*), Broad-winged Hawk (*Buteo platypterus*), and Swainson's Hawk (*B. swainsoni*). The migration bottleneck is a result of two features of the regional landscape. Flights are limited to the east by the Gulf of Mexico, and to the west by the availability of thermal convection. Thermal convection decreases as elevation increases, and is higher in spring than in fall. Stronger thermal convection limits our ability to record migration: it contributes to variation in geographic distribution patterns, altitude of flight, and overall conditions for migration recording.

The second chapter presents a quantitive description of the temporal dynamics of an assemblage of one species of vulture and 11 species of diurnal raptors and uses these measures of intra- and inter-annual variation to make some inferences about the effects of variables at multiple scales in species' migration patterns. I also use this information to evaluate the implications of these temporal variations on long-term monitoring schemes.

The patterns I present are a species-by-species description of spring and fall migration, and a characterization and quantification of the structural patterns of the complete assemblage. During spring, migration is unimodal in seven species and has a bimodal/unclear distribution pattern for five species. Species' migration through the region lasted between 43 and 70 days (mean=53 days). The migration season of four species is significantly shorter in spring than in the fall. I found significant differences in timing of migration across years for all species, with peak dates differing between 3-11 days. In fall, migration is unimodal for ten species. Mean duration of fall migration recorded ranges between 20-74 days (mean=52 days). The duration of fall migration was significantly shorter than spring for five species. With no exceptions, all species had significant differences in timing of migration across years, with peaks differing between 4-9 days.

The third chapter examines the differential flight performance among species and migration seasons. I studied the behavior of nine species of large soaring birds and quantified their wing beat frequency, a commonly used measure of flight performance. There are significant differences among species' wing beat frequency, and larger birds tend to require less energetic expenditure in their flights. I also found seasonal differences in wing beat frequency in seven species, and, contrary to my predictions, spring is a season that demands higher energetic expenditure (higher wing beat frequency) for more species than fall.

My last chapter covers the topic of using of migration count data from Veracruz to assess population trends of New World vultures and diurnal raptors. I evaluated the use of migration counts to monitor populations and obtained annual estimates of population change for five species over a 10-year period. In those five species, who meet both an a priori accuracy target goal and the assumptions of a recently developed regression method, I found significant population increases.

The populations of Turkey Vulture (*Cathartes aura*), Osprey (*Pandion haliaetus*), Cooper's Hawk (*Accipiter cooperii*), Broad-winged Hawk (*Buteo platypterus*), and Swainson's Hawk (*Buteo swainsoni*) have been increasing at a rate between +1.6 and +11.1% $year^{-1}$ and a mean cumulative increase of 26% between 1993-2004. I was unable to assess population trends in 28 species that had very high coefficient of variation in annual counts, less than 100 individuals recorded per field season, and/or shorter field coverage of their migration period.

What is significant in my research is the generation of baseline information on raptor, vulture, and wading bird migration ecology from one of the very few sites in the Neotropics where a long-term research and monitoring program has been sustained. This research has some immediate conservation applications, particularly the use of systematic migration counts to monitor the populations of many species.