

INTRODUCTION

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Studies of foraging behavior and food resources comprise part of an overall attempt by biologists to associate behavior, distribution, and abundance of birds to their biotic and abiotic environments. This is part of a natural progression. Inferences about bird-habitat relationships lead to questions involving environmental requirements, including those of food availability and the birds' use of that food. Studies of foraging in this century began with qualitative descriptions of habitat and foraging locations and advanced to more quantitative analyses of food habits and foraging behavior. Field work in the 1970s and 1980s emphasized quantification of rates of movement, intersexual and interseasonal changes in resource use, and even experiments designed to assess the impact of birds on their prey. In the early 1980s, an increasing number of studies related the "use" of prey or substrates to their "availability," because theoretical developments suggested the importance of these factors for assessing interactions within and among species.

Exploration of any biological process, including foraging, often proceeds logically from a theoretical framework to study design, data collection, data analysis and interpretation, and, finally, publication. It seems to us that contemporary biologists have given much attention to the theoretical framework (e.g., habitat selection, foraging theory, competitive interactions) for their studies, as theories have received extensive attention in the literature. Furthermore, biologists are gaining an appreciation for the value of proper statistical analyses of their data. Unfortunately, much less attention has been given to the intermediate step of study design: duration, temporal and spatial scale, number and training of observers, needed sample size, independence of observations, and the usually complex interactions among these and other factors. Conclusions based on poorly designed studies are suspect, and usually such studies cannot be rescued by statistical manipulations.

We believe that careful attention to study design is an essential precursor to every investigation, and a primary objective of this symposium is to focus attention on those aspects that pertain to foraging studies. As numerous papers in this symposium show, rigorous design features required for an adequate study have seldom been met in the past. While this is not a reason to discard all previous literature on avian foraging behavior, it does require researchers to decide critically which previous literature meets the standards that current research shows to be necessary.

This symposium emphasizes *what, when, where, and how* data on avian foraging behavior should be collected. It is not merely a compilation of natural history notes, although much good natural history will be found here. The various papers deal with aspects of sampling methods, foraging behavior, food resources, foraging theories, sources of bias, needed sample sizes, and so on. Specifically, these proceedings have been divided into six major subject areas:

Role of Birds in Natural Ecosystems and the Quantification of Resources

Quantification of Resources

Quantification of Diets

Foraging Behavior: Design and Analysis

Observations, Sample Sizes, and Biases

Intraspecific, Spatial, and Temporal Variables

Analytical Methods

Specialists Versus Generalists

Energetics and Foraging Theory

Energetics of Foraging

Behavioral and Theoretical Considerations

Alert readers will soon realize that many problems bedevil studies of avian foraging behavior. As shown herein, the challenges of sampling variable food supplies; accounting for observer variability; phenological, seasonal, and annual variability; geographic variability; sex and age-class variability; and the extraordinary sample sizes often needed, all result in high costs in time and money, and will put extreme demands on our ability to design and execute future studies. These considerations must be recognized in advance of initiating any study.

It is probably wise for us all to admit that it may be impossible to conduct many of the studies we would like to, given the many factors—and their interactions—that influence bird foraging. Critical here is the clear statement of objectives, followed by careful evaluation of how each type of variability will be addressed and the number of samples necessary to attain those objectives. Attempting to address multifaceted objectives with inadequate sampling effort gives results with little or no predictive ability; and predictability is one of the goals of scientific research! The result is paper after paper presenting empirical results, but no concomitant refinement of theory. Without increased attention to, and discussion of, study design, progress in this and other aspects of avian ecology will be slow.