Research in tropical forests ought to include: (1) identifying and characterizing threatened habitats and their avifaunas; (2) successful establishment and maintenance of sites where long-term studies (Tinkle 1969, Wiens 1984) can be carried out; (3) immediately identifying areas that are doomed, and facilitating salvage collecting (of specimens *and* of observations); (4) the mapping of species' ranges; (5) ascertaining breeding bird densities in diverse habitats; and (6) monitoring changes in bird populations.

We can individually conduct research along these lines in tropical forests, stress the importance of such research to our students, actively seek the cooperation of indigenous tropical biologists, and extend ourselves to recruit and use local students as assistants in tropical countries. Well-trained, environmentally aware local scientists will have the greatest impact upon the conservation policies of such countries. We also should work collectively through our societies, such as the A.O.U. The British Ornithologists' Union, for example, has performed valuable services regarding tropical avifaunas. It regularly sponsors expeditions, using students and local trainees (e.g. the Mascarene Island Expedition and the Southeastern Brazilian Forest Bird Project). It also supports International Council for Bird Preservation and International Union for the Conservation of Nature projects, and important long-term operations such as the Ngulia, Kenya, ringing (banding) program.

The A.O.U. ought to support Asian, African, and Latin American ornithologists, especially younger ones, in attending the International Ornithological Congresses. It should be officially represented at the Ibero-American and Pan-African congresses, and fund native ornithologists and students in attending them. Cooperative ventures could be undertaken with the I.C.B.P. *The Auk* ought to include French and Spanish summaries of its articles—Spanish, French, and English are understood by virtually all trained persons in Africa, the Neotropics, and much of Asia.

After World War II members of the A.O.U. rallied to prepare aid packages of clothing, binoculars, and books to go to colleagues in a Europe devastated by war. We should now be collecting used field glasses, ornithological and other conservation-related books and reprints, and even typewriters and other equipment for colleagues and students in tropical countries. This could be done by the A.O.U., or perhaps by institutions "adopting" sister institutions in critical countries.

Only effective actions now can minimize the loss to ornithology and mankind of great numbers of tropical forest birds.

LITERATURE CITED

FRIEDMANN, H., & J. G. WILLIAMS. 1971. The birds of the lowlands of Bwamba, Toro Province, Uganda. Los Angeles County Mus. Contrib. Science, No. 211.

MYERS, N. 1982. Depletion of tropical moist forests: a comparative review of rates and causes in the three main regions. Acta Amazonica 12: 745–758.

SHORT, L. L. 1973. (Letter to Editor—Tropical rain forests). Science 101: 893–894.

TINKLE, D. W. 1969. Evolutionary implications of comparative population studies in the lizard *Uta stansburiana*. Pp. 133–154 *in* Int. Conf. Syst. Biol., Univ. Mich., 1967, Systematic Biology. No. 1692. Washington, D.C., National Acad. Sci.

WALTON, S. 1980. Replacing trees with wasteland: the demise of tropical moist forests. BioScience 30: 377–380, 428.

WEINS, J. A. 1984. Editorial. The place of long-term studies in ornithology. Auk 101: 202–203.

Received 14 March 1984, accepted 24 May 1984.

How Long is a Long-term Study?

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The case for long-term studies in ornithology was argued effectively by Wiens (1984): "a long-term approach that spans the periodicity of the normal dynamics of the system is essential," as it is "that granting and funding agencies recognize the need for long-term . . . support . . . and adjust their award structures accordingly . . . ." A question for both proposer and funder is: What is a reasonable time scale for the study of a particular species? If exogenous factors are the only ones involved, plans must be based on knowledge of periodicities in the environment of study. Body size, however, appears to dominate the temporal scaling of life histories (Western and Ssemakula 1982, Calder 1984, Peterson et al. 1984).

For example, the maximum lifespan of a hummingbird (3.5-g *Selasphorus platycercus* females in nature) is 8 yr, and their life expectancy is only 1.8 yr (Calder et al 1983). The scaling for birds in general is that an order of magnitude in size increase is associated with a 50% increase in maximum and the more than doubling of expected lifespan. Nine years of study of 11-g *Parus* are thus equivalent in terms of

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population dynamics to 24–245 yr in a gull colony. The age-dependence of mortality in birds has been obscured by swamping effects of predation, disease, accidents, and (or) crude data (Botkin and Miller 1974), so life-expectancy predictions are similarly crude. More long-term studies are needed to clarify this.

The average life expectancy should equal the turnover time of a population. With refinement of life-expectancy allometry, we would have a basis for gauging the proper duration of long-term studies better, at least as far as the endogenous component in declines and recoveries of populations and the turnover of individuals influential in learning behavior are concerned. For the time being, ball-park estimates can be made as follows: (m = body mass, g):

$$\text{life expectancy, yr} = 0.41\ m^{0.46 \pm 0.083} \quad (r = 0.836);$$

$$\text{maximum longevity, yr} = 6.60\ m^{0.18 \pm 0.052} \quad (r = 0.698)$$

(Calder 1984).

Of course, these estimates are only first approximations. Predicted longevities should be used with the realization that size could account for 70 and 49% of the variation in the data (n = 14, 15), respectively. A standard error, give or take, could alter predictions for a 1-kg bird by factors of +79% to −44% and +43% to −30%, respectively.

Allometric equations also can provide a baseline perspective for interpreting results of long-term studies. Two examples from studies of vulnerable or endangered animals will illustrate this. Ray (1981) characterized the maturation of sea otters and three species of Pinnipedia as being "fairly early," whereas three cetaceans matured "fairly late." His basis of comparison was unstated. Compared with predictions from the allometry of "typical" (terrestrial) mammals, however, of the marine species listed by Ray, the sea otter, fur seal, sea lion, and harbor seal all mature later than expected, whereas the three whale species mature much earlier (2.3 vs. 5 to 4.5 vs. 20.8 yr). What was neglected, apparently (and what could be important for conservation management decisions) was the size-dependent physiological time scale (Lindstedt and Calder 1981).

"Although the Whooping Crane (*Grus americana*) has become a symbol of our efforts to preserve rare and endangered species and has been the focus of considerable attention for decades, the data required for accurate estimates of many key population parameters are still unavailable .... While a maximum age of 24 yr provides the 'best' fit to the existing census data ... 22 or 23 yr are nearly as good estimates ..." (Binkley and Miller 1980: 434). "Whooping cranes probably have a maximum longevity of 30 years or more; they do not breed until they are perhaps 5 or 6 years of age ..." (Miller and Botkin 1974: 177).

How does existing allometry extrapolate to the size of the Whooping Crane (6.9 kg)? The predicted maximum lifespan is 26–32 yr (Lindstedt and Calder 1981, Calder 1984) and predicted age at first breeding is 3.6 yr (Western and Ssemakula 1982). The incubation period is 19% shorter than predicted from adult size, but the egg size is smaller also, and, based on egg size, the incubation period is only 9% faster. Conversely, the time from hatching to flying is one-third to one-half longer than predicted, quantitatively similar to the relative slowing of reproductive maturity. Comparisons of information on Sandhill Cranes (*G. canadensis*) with allometric predictions manifest parallel differences. This suggests that cranes differ from other birds at the generic or family level and that, in the absence of specific information, scaling from data on similar species could be proper and useful. In a time of great environmental threats and abuses, impact statements and damage surveys are required before adequate background data can be collected. More diversity in our ability to predict or anticipate seems desirable.

LITERATURE CITED

BINKLEY, C. S., & R. S. MILLER. 1980. Survivorship of the Whooping Crane, *Grus americana*. Ecology 61: 434–437.

BOTKIN, D. B., & R. S. MILLER. 1974. Mortality rates and survival of birds. Amer. Nat. 108: 181–192.

CALDER, W. W., III. 1984. Size, function, and life history. Cambridge, Massachusetts, Harvard Univ. Press.

———, N. M. WASER, S. M. HIEBERT, D. W. INOUYE, & S. MILLER. 1983. Site-fidelity, longevity, and population dynamics of Broad-tailed Hummingbirds: a ten year study. Oecologia 56: 359–364.

LINDSTEDT, S. L., & W. A. CALDER, III. 1981. Body size, physiological time, and longevity of homeothermic animals. Quart. Rev. Biol. 56: 1–16.

MILLER, R. S., & D. B. BOTKIN. 1974. Endangered species: models and predictions. Amer. Sci. 62: 172–181.

PETERSON, R. O., R. E. PAGE, & K. M. DODGE. 1984. Wolves, moose, and the allometry of population cycles. Science 224: 1350–1352.

RAY, G. C. 1981. The role of large organisms. Pp. 397–413 *in* Analysis of marine ecosystems (A. R. Longhurst, Ed.). New York, Academic Press.

WESTERN, D., & J. SSEMAKULA. 1982. Life history patterns in birds and mammals and their evolutionary interpretations. Oecologia 54: 281–290.

WIENS, J. A. 1984. Editorial. The place of long-term studies in ornithology. Auk 101: 202–203.

Received 28 March 1984, accepted 14 May 1984.