mental determination of sex. Plausible explanations are given for the advantage of environmental sex determination in the echiurid worm *Bonellia* and in mermithid nematodes that parasitize insects of different sizes. As the author acknowledges, the advantage of environmental sex determination in those turtles and crocodilians in which it is known is less clear.

While paths of equilibria may, with appropriate assumptions, connect many of the mechanisms of sex determination, the development of markedly heteromorphic sex chromosomes is a major deterrent to such shifts; in those reptile groups in which both features have been studied, environmentally determined sex is absent when heteromorphic sex chromosomes are present; the uniformity of male heterogamety in mammals and of female heterogamety in birds and the occurrence of XX/XO systems in large groups of insects, arachnids, and nematodes probably reflect the extreme sex chromosomal heteromorphism seen in those groups. Although empirical studies of the degeneration of one sex chromosome are difficult, an appropriate experimental model probably exists in the hemiclonally inherited genomes of hybridogenetic fishes (*Poeciliopsis*) and frogs (*Rana esculenta*).

The chapters on cytoplasmic sex determination, though interesting, are less convincing to me than others because the cytoplasmic factors are maternally transmitted microorganisms. Neither the assumption that infected females are as fit nor the apparent ascription of genetic fixity to the microorganisms themselves seems appropriate. I could not help wondering whether the great complexity of sex determination patterns seen in the isopod *Armadillidium* was not a result of genetic heterogeneity in the parasite as well as the host. Nevertheless, the model developed is useful in pointing up significant features of the biology of these systems, especially in *Armadillidium*, that need further exploration before a satisfactory explanation of the observations is possible.

The book is well printed and relatively free of defects. A conspicuous misprint on p. 215, substitution of "never" for "always," is easily recognized. The bibliography contains over 600 references; both subject and author index are provided. I found much to think about in this book; I recommend it to general biologists and to anyone interested in broad patterns of evolution.

THOMAS UZZELL
Academy of Natural Sciences, Philadelphia, Pennsylvania 19103

Ecology Around the World

The Ecological Century. A Personal Appraisal. E. BARTON WORTHINGTON. Clarendon (Oxford University Press), New York, 1983. xvi, 206 pp., illus. $27.50.

E. Barton Worthington is a unique example of a highly competent person born in the right place at the right time (1905). He was in school when ecology was just beginning, and he was a student in the first limnology course at Cambridge. Most of the young British scientists at that time wanted experience in the African colonies. Hence it is not surprising that, only a few weeks after completing his degree at Cambridge in 1927, Worthington was involved in a fishery survey of Lake Victoria, and later, in 1930–31 in a study of some more remote lakes of Kenya and Uganda. This represents the beginning. From here on he participated, usually as director, in a steady succession of progressively grander programs. Water was involved in some way in all the projects, and so was ecology. Worthington's conception of ecology gradually developed into an ecosystem approach, which included systems analysis, economics, sociology, and even politics. The book is based on his personal experiences, but it is not an autobiography.

Worthington considers that ecology has gone through a sequential development, which can be categorized roughly by quarter centuries. The first quarter of the 20th century was mainly one of exploration, the second quarter was descriptive except for exploratory work still going on in high and low latitudes, and the third quarter was experimental. The fourth quarter sees ecology as a well-established discipline having wide applications in human affairs. Worthington calls the entire century ecological because of the emergence of ecology as one of the essential factors in planning for the persistence of spaceship Earth and its long-evolved ecosystems.

A mere listing of Worthington's responsibilities would be impressive. From 1933 to 1937 he participated in Sir Malcolm Hailey's survey of Africa south of the Sahara, during which he gradually focused more strongly on the broad ramifications of ecology. He saw many aspects of tropical diseases and parasites, crop pests, the effects of frequent fires, the effects of wild animals and forests on flow regimes downstream, and other environmental phenomena. After these African experiences he served as the first director of the Freshwater Biological Association (FBA) Laboratory on Lake Windermere from 1937 through 1946. During the war the staff was involved in increasing human food derived from the stunted perch in the lake and from silver eels. In the later years of the war and while still director of the FBA Laboratory, Worthington became involved with the Scientific Advisory Mission of the Middle East Supply Center, the chief objective of which was to reduce the dependence of the populace on materials that had to be shipped from Europe. In 1946 he was asked to prepare a 10-year development plan for Uganda. Among other things Worthington proposed a dam just below Owen Falls near the mouth of Lake Victoria, which when completed in 1954 made the lake the largest freshwater reservoir in the world. In addition, Worthington was instrumental in the establishment of the Queen Elizabeth and Murchison Falls national parks, which were highly successful in conserving wildlife up to the demise of Idi Amin's regime.

At the completion of this project, Worthington had wanted to be in England while the FBA Laboratory was being relocated. But instead he was asked to be the scientific secretary to the East African High Commission, the function of which was to set up inter-territory research centers for Kenya, Uganda, Tanganyika Territory, and Zanzibar. This work in East Africa enhanced Worthington's appreciation of "holism" in ecology. Among many other activities, Worthington established a well-designed fisheries research laboratory at Jinja on Lake Victoria, and later established a sea fisheries laboratory in Zanzibar.

A major scientific conference was held in Johannesburg in 1949, which led to the establishment of the Conseil Scientifique pour l'Afrique, of which Worthington was made secretary-general. The chief function here was to coordinate research among all the colonies or regions—English, French, Belgian, and Portuguese—south of the Sahara. This was done by encouraging fundamental or long-term research and by organizing scientific conferences for the discussion of common problems. This "international"

cooperation functioned very effectively until the various colonies withdrew on achieving independence. The loss of South Africa for other reasons was a major setback, which has continued to the present.

After writing a report on these activities in London, Worthington had a choice of three jobs—to become director of fishery research of Britain's Ministry of Agriculture and Fisheries, to return to Cambridge as a senior tutor, or to become deputy director-general (scientific) of the British Nature Conservancy. He chose the last, presumably because of its greater environmental challenges and involvement. His activities at this time (1957–1964) reflect the environmental unrest around the world. He gives three examples of the kinds of disputes he was involved in, two of which were decided in favor of industry but only with major concessions from them and with their awakening to some of the realities of ecology. The other major effort was in establishing national, local, and forest nature preserves, wildfowl reserves, and "sites of special scientific interest." Management plans were needed for every reserve.

But although these activities were in England, Worthington was still involved in specific projects outside the country—in East and Central Africa, Jamaica, and Ethiopia. He became a member of the executive board of the International Union for Conservation of Nature and Natural Resources, and later as vice president he launched an African Special Project, which held a conference at Arushan in Tanzania in 1961. Worthington considered this conference together with a telegram from President Nyerere as a turning point in the direction of regarding wildlife as a resource rather than as a hindrance to development.

In 1964, nearing retirement but with no intention of doing so, Worthington became the scientific director of the International Biological Program (IBP). In the chapter devoted to this enterprise he presents a reasonable summary of what the IBP was all about, of some of its major successes, and of its nonsuccesses. As these were turbulent times politically, many scientific activities were impeded by such events as the conflict between Arab and Jew, wars in Biafra and between India and Pakistan, and the isolation of Cuba and Mainland China. Worthington was responsible for establishing the Man and Biosphere Program in 1972, which involves governments in an IBP-like program, and was involved in the Scientific Committee for Problems of the Environment.

The steamer tugboat S.S. *Kavirondo*, used as a research vessel in the 1927 Lake Victoria fishery survey, with a split-prowed canoe in the foreground, papyrus to the left, and reed swamp to the right. [From *The Ecological Century*]

A Committee of Water Research (COWAR) was begun in 1968, with Worthington representing biology. In 1972 he became president. COWAR sponsored a large international symposium on man-made lakes in Knoxville, Tennessee, in 1971 and another on the environmental effects of irrigation in arid lands in Alexandria, Egypt, in 1976. The approach of both symposiums was ecological. Significantly, COWAR has since been reorganized to include the Union of International Engineering Associations.

In 1976, now 71, Worthington was again looking forward to years of leisure on his farm in Sussex. He was not involved officially in any governmental or international activities, but he consented to be a part-time environmental adviser to Halcrow and Partners, consulting engineers. This obviously has involved him in a number of projects, only two of which are mentioned—the construction of a reservoir in Tanzania for producing rice and the construction of two seaports in Thailand. In both he helped prepare the environmental impact statements that were used in decision-making.

Worthington suggests that if one-tenth of the money being spent on defense were allocated instead to the study and conservation of natural resources we would be more likely than we now are to enjoy environmental harmony in the next century. In the two partnerships that must be realized for effective survival, that of humans with nature is coming along well, whereas that among humans still has a long way to go.

Thus, in 11 short chapters Worthington gives us a glimpse of the development of ecology, based mainly on his experiences in East Africa, modified at the end by wider international activities. Much information the reader would like to have is not given, although likely it is available in the various reports and books cited in the references. Worthington himself is not really a scientist, although he has been a very effective science administrator. Through much of his life he has been concerned with Africa south of the Sahara and its underdevelopment. The new underdeveloped nations there are having many problems, not the least of which is the management of their renewable resources. For this they need a scientific cadre of their own citizens, supported by funds from the countries themselves.

DAVID G. FREY
Department of Biology, Indiana University, Bloomington 47405

Primate Adaptations

Five New World Primates. A Study in Comparative Ecology. JOHN TERBORGH. Princeton University Press, Princeton, N.J., 1984. xiv, 261 pp., illus. $40; paper, $13.50. Monographs in Behavior and Ecology.

Deep in the neotropical forests of southeastern Peru lurk the monkey watchers of Manu. Their alpha male is John Terborgh. His chosen mission is to describe and explain the variation in ecology and social organization of an extraordinarily diverse primate community. Surrounding his field site are natural populations of 13 primate species, a situation most nearly paralleled in the West African and Southeast Asian equatorial forests. The 13 species span an 80-fold weight range from the tiny pygmy