Primate Populations and Biomedical Research

Declining primate populations throughout the world represent serious losses for biomedical research.

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The great value of nonhuman primates in biomedical research is clearly established, and so also is the need for a wide range of species from which investigators can select the best models. It is obvious that no single primate species can serve all research interests, nor can the scientific community fully predict which species may be key models in a particular problem. Several years ago we did not know that the night or owl monkey would become a vital model for the study of human malaria (1). Nor did we know that a herpes virus from a squirrel monkey, when inoculated into marmosets, would provide one of the best models of a viral tumor in primates (2). The systematic utilization of primates in biomedical research is at a very early stage in terms of its potential development.

The greatest danger in this development now is that the world's fauna is disappearing at an increasing rate. Since A.D. 1600, at least 120 major species of birds and mammals have become extinct—a rate several times higher than the natural rate of extinction. At present, about one vertebrate species per year is becoming extinct, and probably more than 100 will disappear from the earth in the next 30 to 50 years. The International Union for the Conservation of Nature (IUCN), a

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scientific organization concerned with the preservation and wise utilization of wildlife and natural resources, now lists 275 species of mammals and 300 species of birds as rare and endangered (3). There are 49 species and subspecies of primates on the IUCN list of endangered mammals. This is more than 10 percent of all living primate species.

Ecologic Vulnerability of Primates

Primates are in special jeopardy for several reasons. In the first place, most primate species are forest inhabitants and are especially vulnerable to worldwide patterns of deforestation, slash-and-burn agriculture, herbicide application, and jungle warfare which occur in many of the world's tropical forests. Reforestation, for example, may affect primates deleteriously because of the extensive trend in Asia and Latin America to reforest with single-species stands, especially eucalyptus. Eucalyptus plantings are popular because of their rapid growth and high productivity, but they are of very little value as food or cover for primates or other forest dwellers.

Second, most primates are graminivorous and frugivorous and are in direct competition with human populations around villages and agricultural lands. The villagers of India, for example, have become decreasingly tolerant of rhesus monkeys and have encouraged the trapping and removal of monkeys from agricultural lands.

Third, in many of the forested hill regions of Asia, throughout peninsular Asia, and in parts of Indonesia monkeys are now commonly hunted by the in-

digenous populations, for food and as a source of medicinal or magic potions, made from the bones and various organs. Changing social mores of the peoples of Asia are eroding the "sacred image" of the monkey and account for a lessening of one-time stringently protective attitudes.

Finally, primates are being trapped in increasing numbers for commercial use. Both the pet trade and biomedical research take large numbers of primates in international commerce. More than 100,000 primates are used for research each year in the United States alone.

Habitat deterioration, pressure of human populations, changing human attitudes, hunting, and trapping—these forces, combined, threatened to decimate primate populations throughout the world. Already, several primate species are approaching extinction.

It is apparent that primate populations can become extinct even in areas where primates are greatly honored and revered. The gibbon (*Hylobates lar*) played a vital role in the art, history, dance, music, and entire cultural heritage of China for more than 2000 years, and was formerly abundant throughout China as far north as the Yellow River and as far west as Chengtu and Lanchow. By the year 1644 the gibbon had become so rare in China that it ceases from this date to figure in the literature, art, and music of the culture; since then it has been of only historical importance (4). Even though the gibbon was endowed, in the culture of ancient China, with wisdom and mystical powers, and had a semireligious role, it still became extinct throughout the country. We shall never know all of the reasons for this extinction, but it probably occurred with the deforestation of China and the destruction of the gibbon's habitat.

From an ecologic viewpoint, an extinction of any desirable animal means a decrease in faunal diversity, hence a decrease in ecosystem stability. From a biomedical viewpoint, each extinction means the loss of a unique source of biological material. It becomes increasingly incumbent upon mankind in general, and upon the scientific community in particular, to undertake more vigorous research and conservation programs to protect endangered primates. Conservation means more than strict protectionism. It means wise use and planned management, based on scientific knowledge.

Patterns of Primate Utilization

With these basic premises in mind, let us consider several aspects of the current situation regarding the supply of primates. There are at least three broad patterns.

1) In the case of some species, such as the rhesus, the African green monkey, the squirrel monkey, and the Java or cynomolgus macaque, there is heavy utilization of abundant populations. These populations may or may not be able to sustain present levels of harvest.

2) Other species are utilized to only a moderate degree for research, but they are less abundant and are feeling the pressure both of a deteriorating environment and of wasteful trapping or shooting. In this category are the stump-tailed macaque, the pig-tailed macaque, some of the marmosets, and the owl or night monkey.

3) Still other species are used very little for research at present, but are in serious danger of extinction due to a loss of limited habitat, waste in non-scientific commercial trade, and the fact that they are rare to begin with. In this category are the lion-tailed macaque of India, the douc langur, the golden marmoset, the red *Colobus*, some of the lemurs, and the orangutan.

In most of these situations there is a lack of scientific knowledge about the true status of the population and the basic population dynamics. It is not necessarily wise, and is possibly dangerous at this stage, to be unduly alarmist about the fate of all these species, but it is equally dangerous to be complacent about those that are not dramatically near extinction. We cannot put all of the above species into a single list of rare and endangered species, nor can we urge for all of them a program of total protectionism. For example, the rhesus and bonnet macaques cannot be considered rare and endangered at present, although populations of the former have been declining markedly. We have virtually no knowledge about *Macaca fascicularis* or *M. maura* populations, and cannot plan intelligent management programs for these species at this time. On the other hand, we do know that *M. silenus* is in serious danger and needs immediate attention, and that *M. speciosa* is in a relatively poor situation and also requires strict conservation attention (5). *Macaca silenus*, the lion-tailed macaque, is not utilized in research, but, due to its unique position as the only truly arboreal macaque, it may at some time become the vital model for a biological problem, and when that day arrives it may be too late. Sugiyama (6) estimated several years ago that the total population of lion-tailed macaques consisted of no more than 1000 animals, and the number is now probably less than that. The common pig-tailed macaque in Malaya has been diminishing markedly under human predation (7), and we do not know the true population status or production rate.

In December of 1969, one of us (Southwick) stopped in Burma for a few days in hopes of finding rich populations of macaques there. Burma has been closed to Western animal traders for 20 years, and it is the only nation in Southeast Asia that has never trapped or exported monkeys commercially. In 3 days of fieldwork in the forests of Pegu, northeast of Rangoon, Southwick found no monkeys, and was told that the villagers and hill people shoot them for food and medicinal potions. There are undoubtedly some macaques in the region, but certainly they do not occur in the abundance he had expected.
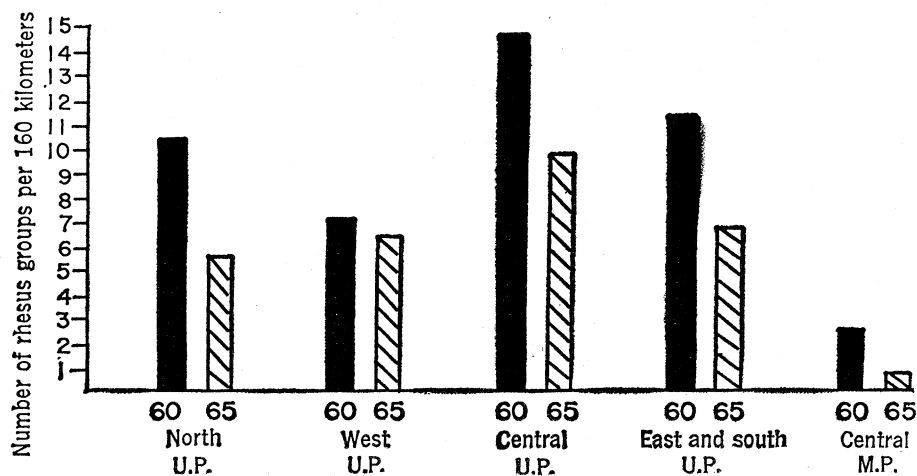

Fig. 1. Relative abundances of roadside groups of rhesus in various regions of northern India, 1960 and 1965. (*U.P.*) Uttar Pradesh; (*M.P.*) Madhya Pradesh.
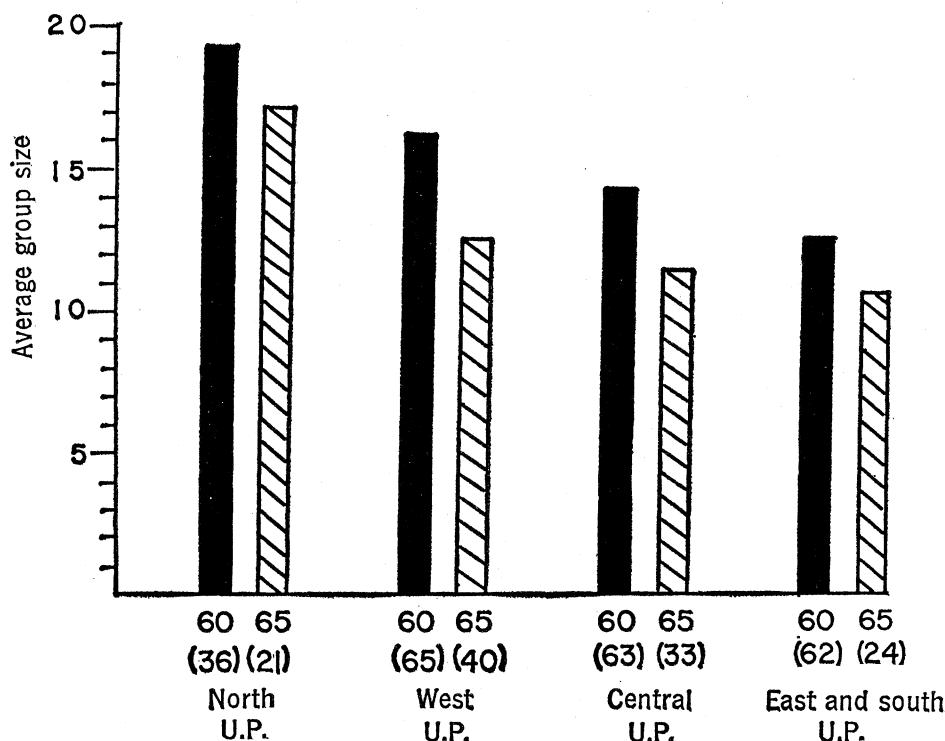

Fig. 2. Relative group sizes of roadside groups of rhesus in various regions of northern India, 1960 and 1965. (*U.P.*) Uttar Pradesh; (*M.P.*) Madhya Pradesh. Values in parentheses are numbers of groups.

Rhesus Populations in India

Several principles of primate population ecology and utilization can be illustrated with data on rhesus macaques in India, gathered over the last 10 years. In September 1959 we began a systematic program of population study in Aligarh District of western Uttar Pradesh in northern India, in which we have censused some 17 groups of wild rhesus every 4 months for 10 years. We are citing this, not as a model study or even an entirely adequate one, but as one representing some of the types of data that are needed to evaluate primate population ecology.

Our first year's work showed that the rhesus populations of northern India were declining in the late 1950's and early 1960's, due to at least three causes. First, most of the villagers were becoming less tolerant of crop depredations by monkeys, and were anxious to rid their area of monkeys. We knew of many instances of villagers trapping or killing rhesus monkeys to save their crops. Second, trapping for export was taking a very large toll throughout the late 1950's—over 100,-000 animals per year, and in some years over 200,000. This was producing a conspicuous change in the age structure of the rhesus population, reducing the relative numbers of juvenile monkeys (8). Third, changes in land use were adversely affecting rhesus populations; these changes included deforestation and single-species reforestation—that is, the replacing of mixed deciduous forests with pure stands of sal (*Shorea robusta*) and eucalyptus, which are less favorable as rhesus habitat.

Through 1964, 1965, and 1966, our population studies showed a continued population decline in rhesus groups in village, roadside, and rural habitats (Figs. 1 and 2). Forest populations seemed to be stabilizing, and town populations were increasing in some areas (9). All populations were showing better age structures, with substantial increases in the juvenile age component. The percentages of juveniles had increased from 5 percent or less to 15 to 20 percent in many habitats. Trapping for export had declined substantially, to less than 50,000 per year.

Our most recent data indicate that a decline in population is still occurring in villages and rural areas, due primarily to cultural and economic forces, but that forest populations may

be reaching a more stable level and that urban monkeys (10) may still be increasing in certain areas. This is not necessarily desirable, because urban monkeys are in relatively poor health, having a high incidence of respiratory and enteric disease, and are a nuisance rather than a valuable animal resource.

Our original Aligarh District population of rural rhesus monkeys, which in 1959 consisted of 17 social groups totaling 337 monkeys, increased to a peak of 23 groups and 403 monkeys in 1962 but since then has shown an erratic decline to the point where it now (in March 1970) numbers only 13 groups and 163 monkeys. Only two of the original 17 groups received protection from the local villagers. These groups have been relatively stable, whereas all the others have declined (Fig. 3).

Our current estimates on the population size and productivity of the rhesus of Uttar Pradesh indicate a population in the neighborhood of 500,000 animals (of which approximately 43 percent are adult females), with an excellent birthrate of 82 percent. We estimate that this population is producing 176,000 infants per year, of which nearly 60,000 could be harvested if certain other ecologic forces were not operative. We feel that planned management of the rhesus population of India could theoretically maintain a substantial harvest, without further diminution. But it is difficult at this stage to predict how extensive future changes in habitat will be, and how much more the Indian peoples' traditional habits of protecting monkeys will erode. With these multiple factors affecting the

rhesus population adversely, we feel that further decline is likely. More emphasis should be placed on monkeys as important national and international resources and less on monkeys as agricultural pests. They should receive careful scientific and managerial attention as major renewable resources.

Even though the rhesus monkey is one of the primate species that has been most thoroughly studied under laboratory and field conditions, there are several aspects of its basic ecology that have never been investigated. To the best of our knowledge no adequate study of the distribution of the rhesus throughout India and Pakistan has ever been made; there has never been a detailed field study made of its food habits in different habitats (except for D. G. Lindburg's unpublished work on the food habits of forest groups around Dehra Dun and M. K. Neville's observations around Haldwani); and there has been remarkably little study of natural diseases in wild rhesus. Our own research is no more than a beginning on what should be done in the area of rhesus population ecology.

Research Needs and Conservation Strategy

We believe there is a danger of undue emotionalism about primate conservation before adequate field data are available. It is likely that biomedical research will receive the brunt of blame for many problems. When shortages of primates occur, the most convenient and visible scapegoat is the research laboratory. We are the first to
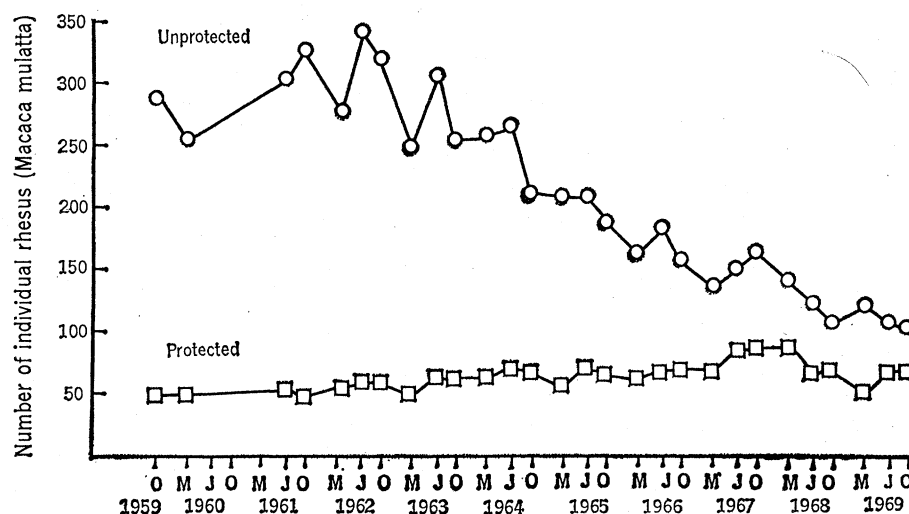

Fig. 3. Trends in populations of unprotected and protected rhesus in Aligarh District, Uttar Pradesh, northern India, 1959 to 1969. Census counts: (*O*) October; (*M*) March; (*J*) July.

admit that excessive harvesting of primate populations may be detrimental, but we also think that other ecologic and social forces are equally detrimental and, in the long run, more serious. The greatest threat to primate populations throughout the world is alteration of the environment, through deforestation, slash-and-burn agriculture, poaching, jungle warfare, food shortages, and excessive utilization of herbicides and defoliants.

For the research community, the practical problem right now is to attach the blame for attrition of primate populations where it belongs: on these corrosive conditions and practices. It is imperative to secure sound field data, in quantity; to bring into more exact focus the true ecologic picture; and to support with this increased flow of data a new thrust in the management of a wise course of conservation practices and programs.

Another danger in excessive alarm is the possibility that some countries may prohibit all export of primates, considering this adequate protection. This would end the activities of legitimate dealers, those with the best and most humane programs, and would stimulate undesirable illegal trade. It could accelerate losses and damage to primate populations by driving the business underground and taking it out of the arena of legitimate governmental and scientific regulation. It would divert attention from the real needs of habitat conservation and scientific management.

At present our most critical need is to obtain data on the population status, trends, and reproductive biology of primates that are used in biomedical research or that represent endangered species. We know little or nothing about the population status of squirrel monkeys, owl monkeys, marmosets, pigtailed macaques, cynomolgus macaques, rock macaques, gibbons, vervets, talapoin monkeys, and several other species of primates that are already important in research. There has been a great flurry of field studies on primates in the last 15 years, but these have been primarily behavioral in nature, and the entire subject of primate population ecology has been neglected.

Although use of primates in research may level out or even decline for a few years, the long-term demand will certainly increase. In the meantime, the inexorable forces of ecology will operate on indigenous primate populations, and they most certainly will be detrimental.

We feel that two major types of programs should be initiated as soon as possible: (i) a coordinated and well-planned program of population research to provide more accurate data on the ecologic status and reproductive biology of important species of primates, and (ii) active conservation programs for all endangered species and all species that are directly utilized in biomedical research. The population surveys are necessary to provide the data on which sound conservation prac-

tices can be based. The conservation programs are essential to insure that some of the world's important primate species will still be here 10 years from now.

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10. Urban monkeys, as distinct from forest dwellers, are groups resident in cities, towns, and villages. They frequent temple areas, railway stations, roadsides leading into the cities, and bazaars. While generally tolerated by people, urban monkeys (outside of temple areas) are often threatened or disturbed in crowded areas. The monkeys in temple grounds are fed and partially protected by local people, yet temple rhesus are more aggressive than forest-dwelling rhesus.
11. The work discussed has been supported by grants from the U.S. Education Foundation in India, and by grants from the National Institutes of Health to Ohio University and Johns Hopkins University. Since 1962, our continuing census work in India has been under the guidance of the Johns Hopkins Center for Medical Research and Training, based in Calcutta. We are indebted to M. A. Beg, R. K. Lahiri, M. Bertrand, P. Jay, D. G. Lindburg, M. K. Neville, and R. P. Mukherjee for field assistance; to M. B. Mirza, J. L. Bhaduri, F. B. Bang, C. Wallace, A. Craemer, R. Yager, H. Kingman, and N. Alim for administrative support; and to B. Harrisson for reading the manuscript.

Policy Framework for Educational Research

A seven-part structure is described for analyzing research policy initiatives.

Hendrik D. Gideonse

Major new research initiatives have been proposed by the Nixon Administration in the field of education. The President himself proposed in his education message that a new National Institute of Education be created to house, sponsor, and coordinate an improved and expanded federal effort in educational research and development. Experimental schools were high on former HEW Secretary Finch's priority list. Meanwhile, it is being suggested that existing programs be focused more sharply on problems of great importance, areas of potential promise, or outputs of potential impact.

These new initiatives follow a 3-year period during which educational R & D has been subject to no less than 16 studies or reviews, 13 bearing directly on the field or major portions of it and the remaining 3 embracing it as part of their broader concern for the behavioral and social sciences generally. The most thorough of the reviews was recently completed under the sponsorship of the Organization for Economic Cooperation and Development (OECD) (1). This review firmly documented the absence of any *de jure* national research policy for education. Nonetheless, rapid development in this field in the past 4