Letters

Self-Regulation of Populations

Wynne-Edwards' article on "Self-regulating systems in populations of animals" (26 Mar., p. 1543) presents not only some worthy conclusions but also a point of view which deserves greater attention in the biosocial sciences. He describes a biological-ecological system having the characteristics that lend themselves to study by the methods of operations research (systems analysis). These characteristics are complex sets of interacting variables, with inputs and outputs operating within a network of feedback controls. Survival in a biological sense can be seen, in this kind of study, as a cost-effectiveness phenomenon. Biological investigation confines itself more commonly to study of the discrete components of the system rather than to the system itself.

Another element which Wynne-Edwards might have included in his discussion is of importance. Mating and reproduction, with attendant courtship activities, in the higher vertebrates (mammals and birds) must be regarded as a phenomenon which necessarily involves a system of communication between at least two members of a species. In order for this system to be effective in bringing about propagation there is required, for each species, a very specific set of environmental conditions. The specificity of these conditions, as a matter of fact, is a major factor in maintaining the purity of a species, without which there would be much more hybridization than usually occurs. The uniqueness of the environmental constraints necessary for courtship and mating is strikingly demonstrated in the well-known difficulties in getting captive wild animals to mate. These constraints are dependent upon climate, the physiological cycles of individual members of a species, proximity of members, absence of distracting stimuli, a critical level of food adequacy (neither starvation nor satiety is conducive to mating), and so on. Competition and privacy both play a part in both stimulating and repressing mating activities in many animals as well as in man. In other words, mating is dependent upon communication between two members such that a signal must be transmitted by one and received by the other under conditions so specific that response occurs only when many variables are optimum.

Courtship and mating in humans can be seen as a model of the extreme condition of complexity in the communication system necessary for propagation. In other mammals and in birds it is less complex but also less controlled by the individual and thus subject to critical vicissitudes. It might well be that the extinction of species (the passenger pigeon, the buffalo, and so on) can be more properly studied if viewed as a result of communication breakdown rather than of single natural enemies (which can hardly account for complete or near-complete extinction). Similarly, overpopulation (human, for instance) might appropriately be viewed as a result of escalation of the capability for communication.

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. . . As the author points out, primitive man probably employed mechanisms similar to those of other species to regulate population. But contrary to Wynne-Edwards' thesis, modern man has not completely lost social controls over population growth. Otherwise how explain the stationary populations of prewar France and Ireland and the declining rate of increase in prewar United States, Great Britain, and other areas? These populations were not limited by strictly Darwinian controls. Even in the darkest days of the depression the people of these countries were not subjected to famine conditions. The controls were rather a social adaptation to what appeared, at the time, to be limitations in the capacity of the economy (environment) to provide opportunities (support) for a larger population. The controls were social; late marriages and small families were fashionable. Raymond Pearl of Johns Hopkins has made extensive studies of the control mechanisms.

I believe that the present population explosion is due to an apparent removal of the limitations of the habitat. To the man in the street conditions appear favorable. There is general prosperity, and paternalistic governments provide for the unfortunate and subsidize housing, medical care, and other needs. The situation is world wide, though standards vary. In some areas the mere absence of acute famine and epidemic disease is sufficient to encourage population growth; in other areas and strata of society a young couple may require a private dwelling or apartment and assurance of a good job before they marry. The controls exist if the general public feels pressure. The problem is the lag in the feedback mechanism; given the long time between the conception of a child and the need for food and a job, how is the population to be controlled in advance of a famine or a depression?

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. . . Wynne-Edwards postulates that self-regulating population-control mechanisms existed in "primitive man" but have been lost in *Homo sapiens* following the spread of the agricultural revolution. Among "stone age peoples" the "real function" of infanticide, abortion, and abstention from intercourse was "probably not even dimly discerned except perhaps by a few individuals of exceptional brilliance and insight," according to Wynne-Edwards.

Two points might be raised with respect to these remarks. First, I am not certain that many well-trained anthropologists would pretend to discern a *single* "real function" of ritual (and nonritual) practices such as infanticide, abortion, and abstention from intercourse, either among hunting-gathering peoples or, with respect to the latter

two practices, among members of Western societies.

Secondly, why has there been growing concern among many educated peoples of the world regarding the "population explosion"? Why are more and more people using contraceptives or accepting contraceptive practices? Why do we frequently hear that types of legislation should be effected to increase the knowledge and the use of birth-control devices and to legalize abortion? Why do many people attempt to control the size of their families and thereby give their children proper living standards, advanced educations, and so forth? Could these be evidence for at least a remnant of population-control mechanisms in modern man, if such systems were present in pre-Neolithic *Homo sapiens?*

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. . . The self-regulating mechanisms that Wynne-Edwards says existed in primitive man have not been lost. In the ecological interaction between man and his environment, the hostile forces that inhibit population growth are somewhat dependent on man's ability to control his surroundings—his technological power. The constraints that define the level of population saturation are thus partially dependent upon a self-organizing capacity of the constrained population. . . . Modern man expands the constraints from within by improved efficiency in surviving. This produces slack in the system much as does a thinning of population. The system adjusts to the slack in both cases by population "explosion." If the rate at which the constraints expand does not exceed the rate of adjustment, the natural regulatory processes must (and will) do their duty. If inertia and momentum are involved, there will be a time-lag which could be troublesome. . . .

I would like someone to analyze the problem of technological progress versus population explosion and demonstrate the self-regulation that is (or will eventually be) imposed, either willingly through rational self-management, or unwillingly through stress induced by conventionalized rivalry (cold war, keeping up with the Joneses, and so forth) or nuclear self-destruction. . . .

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. . . The economic and demographic transition observed in modern history provides ample evidence of a self-regulating system in human population growth. This system of homeostasis may have been obscured by relating the reduction in the birth rate to the rise in the level of living when, in fact, the reduction in the birth rate appears to be a consequence of the reduction in the death rate.

Longitudinal as well as cross-sectional correlations between economic and demographic variables from 21 countries for which comparable data were available in the postwar era (to be published in *Economic Development and Cultural Change*) indicate strong associations of the birth rate with other demographic variables but weak associations of the birth rate with economic variables. The coefficient of correlation between the logarithms of the decennial percentage changes in the birth rate and the product per capita at constant prices is only −0.23. But the logarithm of the decennial percentage change in natality is inversely proportional to the logarithm of the rate of natural increase in the base year, the coefficient of correlation being −0.73.

Thus, a reduction in the death rate would seem to be the precursor of a reduction in the birth rate. Combination of empirical equations for the relative change in natality and mortality indicates the dynamic equilibrium of economic and demographic transition: Mortality varies inversely with the level of living, and natality, in a balancing movement, tends towards net reproduction at unity.

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Wynne-Edwards neglects to mention the work of other investigators who have already "[drawn] attention . . . to the intimate way in which physiology and behavior are entwined in providing the regulatory machinery" for population control. Data in support of the postulate that density of natural populations operates through physiological adaptive mechanisms to regulate productivity (reproduction and recruitment) were first assembled in 1950 by J. J. Christian (*J. Mammal.* **31**, 247). During the following decade this postulate was expanded to recognize that "social interaction," which is characteristic of the species, rather than density per se, was a major factor in population control and dispersion and in the frequency of disease. A paper by Christian in 1956 (*Ecology* **37**, 258) is an excellent example of a series of studies on the mechanism of density control in confined populations. More recent papers by Christian and by R. L. Snyder [*Proc. Natl. Acad. Sci.* **47**, 428, 449 (1961)] contain numbers of references to the studies of many other highly competent investigators in North America and Europe. The concept of population regulation through physiological adaptive responses to the social environment is not new. Its origins are certainly multiple and its advocates many.

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Women as Graduate Students

Allyn Rule's contention that women are handicapped in obtaining graduate education in science by their family responsibilities and by the inflexibility of many graduate programs (Letters, 2 Apr., p. 21) seems to be supported by evidence. But her third point, that most graduate programs discriminate unfairly against women, is debatable.

In a recent book entitled *Academic Women* (Pennsylvania State University Press, University Park, 1964), Jessie Bernard cites evidence to show that women are admitted to graduate programs on a basis nearly equal to that of men. They also obtain financial assistance, such as fellowships and assistantships, in a proportion equal to that in which they apply for it. The amount of financial assistance available for graduate students is increasing at a rapid rate, stimulated by the influx of federal funds, and many graduate departments find it difficult to locate enough highly qualified students to support. As a result, sex is becoming a relatively unimportant variable in making this decision.

It can be argued, by contrast, that women are receiving more consideration in graduate school admission and in financial assistance than they deserve. The attrition rate among female graduate students is greater than among men, and many women who receive graduate degrees do not make productive use of them for any substantial