The Evolution of Marmot Societies: A General Theory

Differences in social behavior among marmot species are correlated with the harshness of their environments.

David P. Barash

The social system of a species is clearly one of its most important biological characteristics. If we make the reasonable assumption that even complex animal behavior reflects at least some component of genotype, then we must expect social systems to have evolved, just as structure and physiology have evolved. As the products of evolution, social systems should thus be adaptive; that is, they should be peculiarly adjusted to each environment in which they occur so as to confer maximum reproductive success upon their practitioners. Thus, the kaleidoscopic diversity of animal social systems takes on new order and significance when viewed as part of the adaptive mechanics of a species, no less "real" or amenable to scientific analysis than metabolic adaptations for water conservation among desert rodents or stereoscopic vision among arboreal primates.

In recognition of this, the new field of "socioecology" has emphasized comparative analyses of social organization in free-living animals (*1*). By studying closely related species or even local geographic variants of the same species, socioecologists hope that the effects of discrepancies in natural genetic endowment can be minimized, and that the true adaptive nature of social behavior will thus be revealed. While this ideal is rarely achieved, a profitable start has been made, most notably with primates (*2*). However, full appreciation of the range of possible evolutionary adjustments requires that attention be given to a greater variety of species. For the past 7 years I have been investigating social behavior in marmots—large terrestrial rodents of the genus *Marmota*, family Sciuridae. These animals are particularly appropriate subjects for studies of comparative socioecology: they are diurnal, large enough to be easily seen, and relatively insensitive to the presence of a human observer. Because they are burrow-dwelling species, they can be located easily for daily observations; one does not have to make frequent time-consuming searches as one does when studying primates, cervids, or canids. Perhaps most important, the genus *Marmota* is composed of many species (6 in North America, 14 worldwide) whose genetic equipment is probably similar—all marmots have closely comparable morphology—and whose variety of environments appear to correspond with a similar variety of social systems.

In recent years, this relatively neglected group of animals has received considerable paleontological and cytological attention (*3, 3a*) which promises to reveal much of the evolutionary history of the group. There has also been an analysis of social organization in the yellow-bellied marmot, *M. flaviventris*, in which the prevalent social system has been interpreted as a compromise between maximum male and female fitness (*4*). My own studies have now revealed an exciting series of consistent and predictable correlations between marmot environments and social systems that indicate the ways in which social behavior may be adjusted to local ecology.

Environment and Social Biology in Marmots

The woodchuck, *M. monax*, is best known east of the Mississippi, where it most commonly inhabits fields and forest ecotones at low elevations. In such environments, the woodchuck generally experiences a relatively long vegetative growing season, exceeding 150 days in southern Pennsylvania, for example, where the species has been intensively studied (*5*). In this comparatively equitable environment, woodchucks are solitary and aggressive (*6*); the association between adult male and female is essentially limited to copulation, the only lasting social tie being the mother-young nexus, which itself terminates at weaning when the young disperse (*7*).

By contrast, the Olympic marmot (*M. olympus*) is highly social, living in distinct, closely organized colonies usually composed of several adults (most commonly one male and two females), 2 year olds, yearlings, and the young of the year (*8*). This species is highly tolerant and playful, commonly feeding in social groups of three to six individuals. No territories or even distinct individual home ranges are maintained; all parts of the colony are equally available to all colony members. Dominance relationships are generally indistinct and nonpunitive. Olympic marmot social life is characterized by a high frequency of active "greeting" behaviors, previously described for other sciurids (*9*) and apparently associated with individual recognition. Greeting frequencies follow a predictable diel and seasonal cycle—high in the spring and in the early hours of each day. During the early-morning "visiting period" the inhabitants of each colony enter all occupied burrows and exchange numerous greetings with the other colony residents.

Social organization in the Olympic marmot is thus entirely different from that in woodchucks. The environments of these two species are also at opposite extremes: Olympic marmots inhabit exclusively the alpine meadows in Olympic National Park, Washington. Their colonies are located at or above timberline where they experience very short growing seasons of 40 to 70 days. These differences between the two species therefore suggest a possible correlation between length of the growing season and type of social system, the shorter growing season being associated with increased sociality.

Fortunately, marmots living at intermediate elevations have also been studied. The yellow-bellied marmot inhabits a wide range of environments, from sea-level prairies in eastern Washington through a variety

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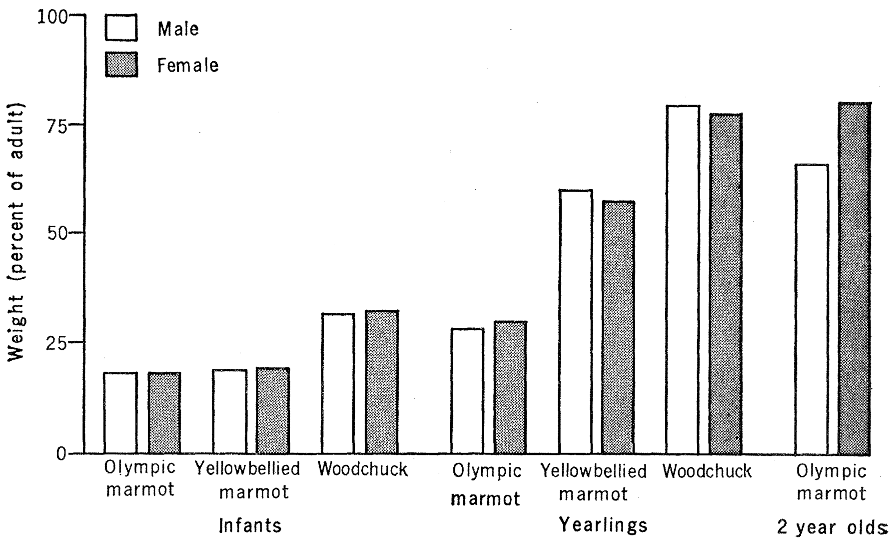


Fig. 1. The percentage of adult weight achieved at different ages by individuals of three species of marmots: the woodchuck, *M. monax*, which is usually found at low elevations and which experiences growing seasons of about 150 days; the yellow-bellied marmot, *M. flaviventris*, which lives at intermediate elevations and has a growing season of about 70 to 100 days; and the Olympic marmot, *M. olympus*, which lives at high altitudes and has a growing season of 40 to 70 days. Relative weights were calculated in each case by dividing the mean weight of each sex and age class by the mean adult weight of the same species at the same time of year. [Reprinted from (*8*), courtesy of *Animal Behavior Monographs*]

of montane meadows in the Sierras, southern Rockies, and southern Cascades. This species has been intensively studied at intermediate elevation in Yellowstone National Park, Wyoming (*10*), where it experiences an appropriately intermediate growing season of approximately 70 to 100 days. It is significant that in this "intermediate" environment, the social system of the yellow-bellied marmot is also intermediate. This marmot lives in recognizable colonies composed of numerous adults, and is thus considerably less solitary than the woodchuck; but individually distinct home ranges are maintained, physical spacing between individuals is relatively great, and infrequent social interactions are overlain with considerable aggressiveness, indicating that *M. flaviventris* has a less highly socialized behavioral system than the Olympic marmot. The highly social Olympic marmots average about one greeting per animal per hour, while greetings in the yellow-bellied marmots average about one tenth of this number, and among the relatively asocial woodchucks, the behavior has not even been described.

Environment and Dispersal

Correlations have also been found between the length of the growing season and the age at which marmots disperse and form new colonies. Woodchucks (long growing season) disperse during the year they are born and often become sexually mature as yearlings; yellow-bellied marmots disperse as yearlings and become sexually mature as 2 year olds; Olympic marmots disperse as 2 year olds and become sexually mature as 3 year olds. This progressive retardation in age of dispersal, correlating as it does with altitude and growing season, almost certainly reflects a progressive increase in the time required for the animals to accumulate sufficient body weight for the biologically demanding acts of dispersal and reproduction. In this regard, the absolute growth rate of a species is less significant than its age-specific relative growth—that is, the percentage of adult weight achieved by individuals as young, yearlings, 2 year olds, or adults. Figure 1 shows that woodchucks achieve 33 percent of their adult weight during their year of birth, at which time they disperse. Both the yellow-bellied and Olympic marmots achieve less than 25 percent of their adult weight during their year of birth, and the young of both these species remain in the home colony with their mothers. As yearlings, woodchucks are 80 percent of adult weight and are independent; yellow-bellied marmots are 60 percent mature and disperse; Olympic marmots are still only 30 percent mature and, accordingly, they remain closely associated with their mothers in their home burrow until they are 2 years old. At this point, having achieved 70 percent of adult weight, the Olympic marmots finally disperse and bear their first litter the following (their third) year—1 year later than yellow-bellied marmots and 2 years later than the average woodchuck.

Even if relative growth rates were comparable, the more severe environments experienced by the mountain-dwelling *M. olympus* would probably necessitate progressive delays in age at dispersal and sexual maturation, simply because proportionately greater maturity might well be required for success in environments of greater severity. Given that relative growth rates are actually slower in these environments, retardation of dispersal and sexual maturation becomes doubly essential.

Because it influences dispersal and sexual maturation, the environment of each species may also influence the social system practiced by each one. Thus, selection would favor any social system that conferred maximum reproductive success upon its members and, since each year's dispersing animals represent the accumulated annual genetic investment of the species, selection would favor those social systems that conferred maximum success upon its dispersers. Aggressive behavior in the adults has been implicated in the initiation of dispersal among yearling yellow-bellied marmots (*11*) and, if one considers the aggressive nature of the woodchuck, a similar correlation can be expected in this species. In fact, the greater aggressiveness of woodchucks may well be related to their dispersing at an earlier age. Dispersal in Olympic marmots is delayed even longer than in yellow-bellied marmots and, in fact, longer than in any marmot species studied. This delay, made necessary by the severe environment, may well be made possible by the most tolerant marmot social system yet described. Given an apparent causative relation between aggressiveness and the onset of dispersal, selection acting in each environment may have favored that degree of aggressiveness which results in optimum age at dispersal. The progressive increase in sociality among marmots experiencing progressively shorter growing seasons may thus be due to the increasing necessity to inhibit the dispersal of undersized animals.

Dispersal among Olympic marmots proceeds gradually. The 2 year olds become progressively more prodigal, spending longer periods at greater distances from their fellow colony members, until eventually they overnight at a burrow peripheral to the main colony. This last step may be very significant, because upon emergence the following morning, such a 2 year old misses the early-morning visiting period. When it eventually wanders back to the colony residents, it may be rebuffed—often violently—in which case it leaves the colony permanently. This brief but intense aggressive response by the colony residents thus appears to initiate the 2 year old's final break with its colony affiliation. I tested the effects of short periods of absence by live-trapping individuals of different age and sex classes, withholding them from their home colony, and then reintroducing them. Without exception, the reintroduced animals were received in an unusually aggressive manner, far exceeding the normal experiences of a colony resident, and corresponding in intensity with the length of their absence (*8*). Thus, although high aggressiveness is not normally characteristic of Olympic marmot colonies, the actual initiation of dispersal is indicative of the correlation between aggression and dispersal that is so prominent in the other less tolerant marmot species.

A Behavioral System of Local Population Control

Although all dispersal among Olympic marmots is performed by 2 year olds, not all 2 year olds disperse. This species has evolved a unique, density-dependent system which annually adjusts dispersal to local population size, so that colony population remains relatively constant from year to year, regardless of the annual fluctuations in mortality. Mortality among Olympic marmots occurs primarily during the winter and is particularly high among the hibernating young. The number of marmots that die during winter is a function of snow cover, hibernating marmots being dependent upon the insulating capacity of snow. During a winter in which there has been a consistent snowpack, mortality is generally light (*8*), but sudden, warm January rains and heavy winds not uncommonly denude the Olympic Mountains of snow, leaving the hibernating animals vulnerable to sudden cold spells that often follow. After a winter of heavy snow (low mortality) colony populations tend to be large upon emergence the following spring. In such circumstances, all 2 year olds generally disperse. However, after a winter of high mortality dispersal is inhibited, and the 2 year olds remain as permanent colony residents. Intermediate mortality results in intermediate numbers of 2 year olds dispersing (*8*).

This system of regulated dispersal is clearly keyed to colony size. I attempted to investigate its behavioral components by comparing social interactions at a large colony, from which all 2 year olds eventually dispersed, with a small colony from which there was no dispersal. The 2 year olds at the large colony were subjected to essentially the same amount of aggression as those at the small colony (Fig. 2). Furthermore, the adult females at both colonies experienced significantly more aggression than did the 2 year olds, yet the 2 year olds eventually dispersed, not the adult females. Accumulated aggression was clearly not responsible in itself, unless one postulates a lower tolerance threshold among the 2 year olds. Comparison of greeting frequencies, however, revealed a significant difference between the social behavior of 2 year olds from large as opposed to small colonies (Fig. 3). The 2 year olds at the large colony engaged in significantly more per capita greetings than did the 2 year olds at the small colony. In addition, at the large colony the 2 year olds experienced significantly more greetings than any other class. Apparently, a large population in the spring results in heightened social activity which is especially reflected in the social experiences of the 2 year olds, who

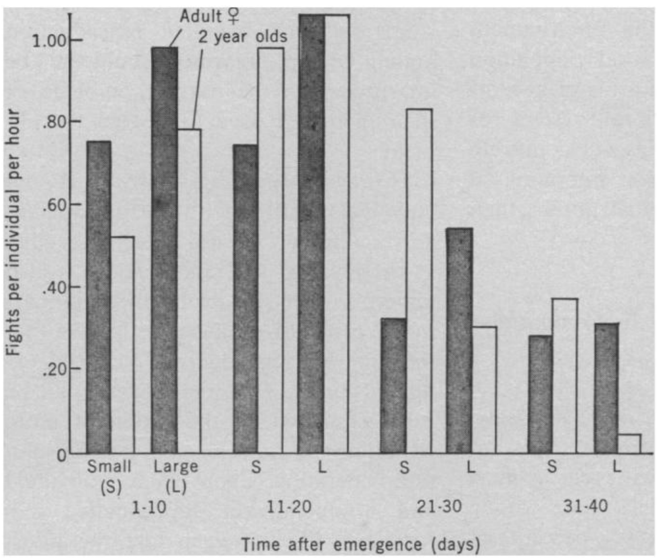
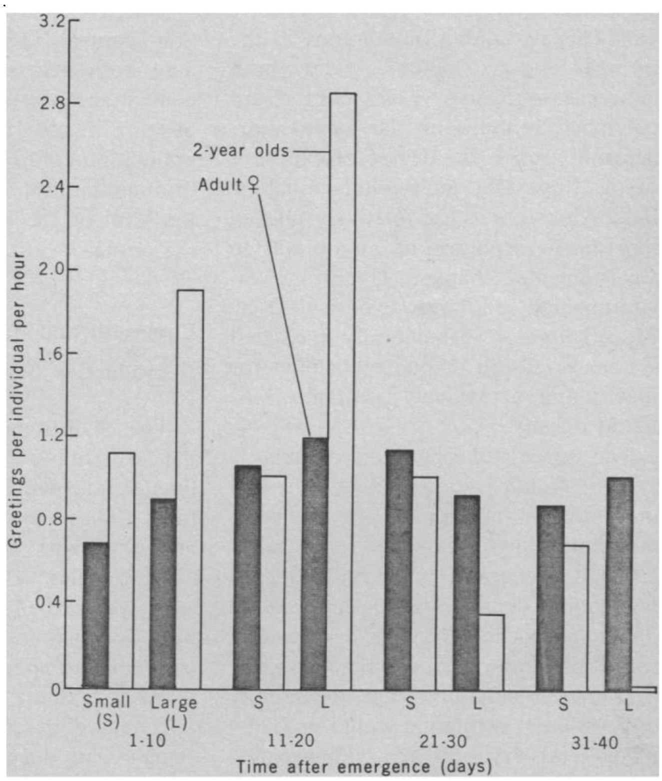


Fig. 2 (above). Frequencies of fights experienced by 2 year olds and by adult females of *M. olympus* at a small colony and a large colony, after the individuals emerged from hibernation. [Reprinted from (*8*), courtesy of *Animal Behavior Monographs*] Fig. 3 (right). Comparative total frequencies of greeting behavior in 2 year olds and in adult females of *M. olympus* at a small colony and a large colony. [Reprinted from (*8*), courtesy of *Animal Behavior Monographs*]



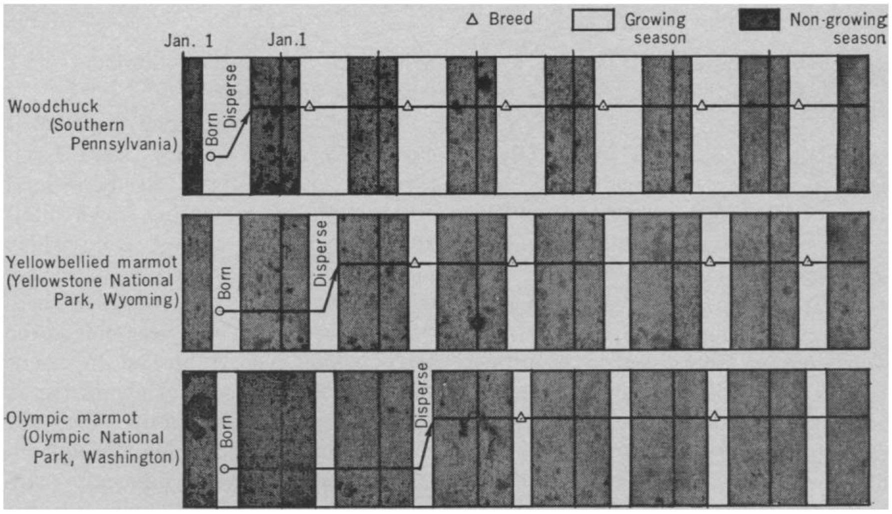


Fig. 4. The correlation of length of growing season with age at dispersal, age at sexual maturity, and breeding system in the woodchuck, yellow-bellied marmot, and Olympic marmot. [Reprinted from (*8*), courtesy of *Animal Behavior Monographs*]

respond by wandering increasingly far from their native colony, eventually to disperse. Further details of this system have been discussed elsewhere (*8*). A physiological model relating environmental stimulation to an animal's level of nonspecific activation has been proposed (*12*) and may suggest the type of internal mechanism that controls behavior under the conditions described here.

The evolution of a behavioral system of local population control would be particularly appropriate in the Olympic marmot, because the maritime climate of the Olympic Mountains produces winter snow conditions that are characteristically variable. Thus, mortality (and, hence, colony populations in the spring) tend to fluctuate widely both between successive years and from colony to colony in the same year, depending upon the degree of exposure of the slope that each colony inhabits. Behavior refers to the relatively plastic, short-term responses of an animal to environmental changes. Under the environmental conditions experienced by *M. olympus*, a behaviorally mediated system would be uniquely qualified for maintaining a relatively constant population density.

The successful operation of such a system would require close physical proximity of the animals and, hence, a moderately high degree of social tolerance. Its accuracy as an indicator of population density would decrease in direct proportion to the degree that social intolerance reduced the frequency of social interactions. The desirability of population regulation would probably increase as environments with progressively shorter growing seasons were inhabited, because not only would the entire habitat be easily overgrazed and damaged, but there would be strong competition for available food within each colony. Such competition would be dangerous because of the presence of the older animals whose dispersal has itself been prohibited by the occupation of these environments. Accordingly, social tolerance and colonial organization, which may have evolved among the marmots in proportion to their occupation of increasingly severe and isolated environments, would become increasingly advantageous in that it potentiates an efficient behaviorally mediated system of intracolony population control. Thus, the environment may both necessitate local population control and provide a means of accomplishing it. A behavioral system of population control could evolve entirely through natural selection operating at the level of the individual, rather than the group.

Environmental Factors in Comparative Reproductive Performance

The environment or, more precisely, the availability of nutrients, also influences the reproductive cycle in marmots. Thus, woodchucks bear young annually, with 90 to 95 percent of adult females becoming pregnant each year; yellow-bellied marmots may also bear young annually, but they not uncommonly skip a year; and Olympic marmots exhibit the slowest reproductive rate yet described for any rodent—females produce litters in alternate years only (*8*). These different reproductive cycles (Fig. 4) reveal the consistent influence of adaptation to progressively more rigorous environments.

Studies of male-female behavioral interactions in the early spring following seasonal emergence revealed that nonparous years in the Olympic marmot are not caused by miscarriage or death of the offspring, but rather by each female simply skipping estrus in alternate years (*8*). In addition, histological analysis of the ovaries of nonparous adult females revealed well-developed medullary cords, but otherwise mature gonads, lacking in corpora lutea. Biennial breeding is thus apparently a genetically determined characteristic of this species, just like annual breeding in the woodchuck.

Olympic marmots superficially appear capable of reproducing more frequently than they do, especially if one considers the prolific traditions of rodents in general. The mere suggestion that any animal is reproducing at a rate below its maximum capabilities indicates a condition of considerable evolutionary interest. One possible explanation, which utilizes the notion of "group selection" championed by Wynne-Edwards (*13*), is that the occupation of potentially fragile environments of limited area makes an "altruistic" restriction upon reproduction increasingly desirable—for the benefit of the group (that is, the colony). The disadvantages of local overpopulation become greater among marmots subjected to progressively shorter growing seasons, so that biennial reproduction among Olympic marmots could thus be interpreted as the natural outcome of their increased need to restrict recruitment.

However, such an analysis is not only incompatible with the general understanding of natural selection acting at the level of the individual, it is also unnecessary as an explanation of marmot reproductive biology. I believe that the unique reproductive strategy exhibited by the Olympic marmot can be fully explained by the action of more "traditional" natural selection—evolution operating upon each individual and producing the reproductive performance likely to generate the maximum number of surviving offspring. Most notably championed by the late David Lack (*14*), this concept recognizes that maximum effective reproduction may often be achieved by employing what superficially appears to be a submaximum reproductive strategy.

There are several possible explanations for biennial breeding being a system that provides maximum reproduction for a species such as the Olympic marmot. Pregnancy clearly imposes a physiological strain upon mammals and, in a species experiencing a very short growing season, an alternate "off" year may be necessary to replenish metabolic losses. In addition, although the food of marmots does not appear to be limited in the early summer, marmots must eventually accumulate sufficient fat for their hibernation to be successful. Olympic marmots deplete the available meadow vegetation by late summer and early autumn and, during particularly dry summers (not uncommon in the variable climate of the Olympic Mountains), intracolony competition may be severe. Since inhabitants of a single colony are generally close relatives, kinship selection (*15*) may mitigate against annual reproduction with its attendant heightened competition between genetically similar individuals.

Finally, there are two further points of interest in Olympic marmot social behavior: (i) yearlings generally continue to live in the same burrow with their mothers and (ii) parous females are relatively aggressive to all other animals, vigorously defending the burrow in which they give birth and in which their young remain until they disperse as 2 year olds. The former behavior suggests that cohabitation with the mother is advantageous to the yearlings, while the latter suggests that the elimination of other animals from the natal burrow is advantageous to the young of the year. Consider then, a hypothetical Olympic marmot breeding annually: with each litter the female could either chase out her yearlings (to their probable detriment) or allow them to remain (to the probable detriment of her current young). Either way, the annual breeder would sabotage her own genotype each year. However, no direct comparison of annually and biennially produced offspring can be made because only biennial breeding has been observed in the Olympic marmot.

Whatever the ultimate explanation, the severe environment and short growing season experienced by the Olympic marmot is clearly related to its unusually slow reproductive rate and to other aspects of its social biology. For example, retardation of dispersal until the age of 2 years—that is, until the third year—might seem to inflate colony size and thus "require" reduced recruitment to prevent overpopulation. This argument is itself teleological and implies group selection—I therefore find it unacceptable. However, the coincidence of delayed dispersal (and its correlated system of social tolerance) with reduced recruitment is clearly not fortuitous since the same basic ecologic factor—short growing season—is ultimately responsible for this entire system of adaptation. Furthermore, as the occupied environments are progressively more severe, increased sociality and colonial organization not only makes local population control more desirable (by concentrating individuals in a small area) but also makes it more feasible (through the behavioral system of 2 year olds' dispersal in response to large colony size described above).

Further Testing of the Theory

This general theory of marmot social biology in relation to local ecology was first suggested by my study of the Olympic marmot in Olympic National Park. The theory generates many testable hypotheses and I have been pursuing these ever since. Thus, in 1970 I conducted a study of the hoary marmot (*M. caligata*) in Glacier National Park, Montana. The social behavior of free-living hoary marmots had not previously been described, but since they live in an alpine environment with a short growing season essentially similar to that of the Olympic marmot, I predicted that they would also have adaptations similar to those of the Olympic marmot: colonial organization, social tolerance, late dispersal and maturation, slow recruitment. These expectations were fulfilled (*16*).

The yellow-bellied marmot occupies a wide range of environments and has been most studied at intermediate elevations (*10*). Because of its eurytopic nature, this marmot is an ideal species for determining whether the correlations that occur interspecifically also occur intraspecifically. They apparently do. In 1971 I compared the social biology of two colonies of yellow-bellied marmots in Rocky Mountain National Park, Colorado—one colony at 2650 meters (medium elevation and growing season) and the other at 3850 meters (high elevation and short growing season). Social behavior of the medium-elevation colony resembled that previously described for the same species (*10*) occupying a comparable environment in Wyoming, while the high-elevation colony demonstrated those characteristics described for the Olympic and hoary marmots (*17*). Actually, the agreement of these data with the theory proposed herein is even greater than one might expect, because genetic exchange between locally adapted demes would predictably tend to reduce the degree of local intraspecific adaptation as opposed to the adaptive differentiation already recognized between marmot species.

I have suggested that marmot social evolution in progressively more severe environments involves corresponding decrements in aggressive behavior in order to accommodate the animals' need to disperse at an increased age. Early dispersal among woodchucks is assumed to be a function of the adults' aggression toward the young and, if one considers the woodchuck's generally intolerant nature, this assumption seems reasonable. Quantitative data on this aspect of woodchuck behavior were obtained in 1972, when I live-trapped several pregnant woodchucks and studied normative mother-infant relations in these captive animals. A regular decline in solicitous behavior in the mother toward her young was revealed, along with a steady increase in the frequency of aggressive incidents, peaking at the time dispersal normally occurs in nature (*18*). The evidence for the role of aggression in stimulating dispersal among free-living animals is thus still circumstantial, but nonetheless suggestive.

The genus *Marmota* is believed to have originated among woodchuck-like ancestors in North America during the late Pliocene, spreading to the Old World during the early Pleistocene (*3*). We know very little about the numerous palearctic species, however, and for any theory of marmot social biology to be comprehensive, these animals must also be considered. Although the species *M. marmota*, native to the Alps, would appear to be a prime subject for the attention of European ethologists, I could find no quantitative data on its basic social biology. Accordingly, in the summer of 1973 I conducted a study of the social behavior of *M. marmota* in the French Alps, Vanoise National Park (*19*). In this mountainous region, the Alpine marmot experiences short growing seasons and appears to have, appropriately, a social system similar to that of the Olympic marmots, with one basic exception. Frequencies of greeting behavior, employed in my previous studies as a convenient indicator of sociality in North American marmots, are consistently and significantly lower in *M. marmota* than among *M. olympus*. Yet, physical proximity, chasing, and play-fighting frequencies indicate comparable social tolerance and colonial organization. This finding suggests the need for a multiple-parameter approach to the evaluation of comparative sociality, since the evolution of social behavior in the genus *Marmota* has apparently involved the independent elaboration of various distinct social characters. In addition, annual breeding appears to be the rule in *M. marmota*, although biennial reproduction might be anticipated. The case of this species may be somewhat confounded, however, since it appears to be a recent inhabitant of high-altitude meadows, where it is a refugee from human hunting pressures. In any case, litter size in *M. marmota* appears to be significantly smaller than in the Olympic marmot, suggesting that the former may achieve the same ultimate reproductive modification by a different proximate strategy.

Further studies are clearly indicated: the steppe-dwelling Asian marmots require attention, as do the little-known Vancouver and Brower's marmots of North America. In addition, the general theory described here would predict adaptations approaching those of the woodchuck among yellow-bellied marmots living at low elevations in eastern Washington, and adaptations similar to those of the Olympic marmot among woodchucks at high latitudes in Alaska. Much remains to be learned.

The marmots present an unusually good system for the ecological and evolutionary analysis of social systems in vertebrates. If anything, the correlations revealed between environment and social behavior in marmots may appear to be too distinct at present, the adaptive values too obvious. There are more predictions to be tested and further studies may well show that the theory of the evolution of marmot societies described herein is far more complicated than it now seems to be. Konrad Lorenz has suggested that biologists should practice discarding one cherished notion every day before breakfast. In any case, continued efforts should advance the goals of socio-ecology by further revealing the correlation between environment and social biology within this genus.

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20. K. B. Armitage and J. Downhower kindly permitted access to their unpublished data, although they are not responsible for the interpretations here presented. This article is affectionately dedicated to Dr. John T. Emlen, Jr., on the occasion of his retirement after many productive and inspiring years with the Zoology Department of the University of Wisconsin.

NEWS AND COMMENT

Test Ban: Arms Control Groups Denounce Summit Treaty

The threshold nuclear test ban treaty signed at the recent Moscow summit will not be ratified by the U.S. Senate if ratification depends upon the support of those scientists and independent arms control specialists who have been trying longest to put the nuclear genie back in the bottle.

The American and Canadian Pugwash executive committees have described the proposed treaty as a "mockery" (see box). The Arms Control Association (ACA) has decided to oppose the treaty as worse than no treaty at all. The Federation of American Scientists (FAS) regards the treaty as a "counter-productive sham" and will urge that the negotiators return to the bargaining table and seek a better one.

Taken together, the ACA, the FAS, and the American Pugwash participants—these groups actually overlap in membership and even in their leaders—represent an influential source of advocacy and advice on arms control issues. They often have been critical of Administration arms policies.

Among the Pugwash participants are such eminent figures as George Kistiakowsky of Harvard, once science adviser to President Eisenhower; Harvey Brooks, Harvard dean of engineering and applied physics; and Bernard Feld of MIT, secretary-general of Pugwash. Feld is also a leader of the Council for a Livable World, a group formed in the early postwar years which is close to many of the senators most interested in arms control because of its financial contributions to their election campaigns. Feld and Kistiakowsky, along with certain other American Pugwash scientists, have been outspoken critics of U.S. policies in regard to nuclear arms.

The FAS, a Washington-based group with a membership of 6500 and a list of sponsors that includes 33 Nobel laureates, was established in 1946 as the "Federation of Atomic Scientists" and has always viewed the control of nuclear weapons as an overriding concern.

The ACA, which has about 400 members, was formed in Washington in 1971 by a number of individuals with extensive experience in the field of arms control. Its officers and directors include persons such as William C. Foster, former director of the Arms Control and Disarmament Agency (ACDA); Herbert Scoville, Jr., former director for science and technology at the Central Intelligence Agency and later assistant director for science and technology at ACDA; and Herbert F. York, who was once director of defense research and engineering in the Department of Defense.

The Moscow treaty puts these several groups of arms control advocates in an ironical posture. They generally