of antibody diversity and the mechanism of evolution in a multigene system. Indeed, it seems likely that other complex mammalian systems should employ a similar strategy for information storage and transfer, and hence the immune system should serve as a useful general model for differentiation in higher organisms

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Bare Zone between California Shrub and Grassland Communities: The Role of Animals

Abstract. Between shrub and grass communities in coastal California there is a zone that is normally bare of vegetation. Previous studies have emphasized the role of volatile inhibitors of plant growth in producing this bare zone. However, there is a concentration of feeding activity by rodents, rabbits, and birds in this zone; if this activity is prevented by means of wire-mesh exclosures, annuals grow in the bare zone. Thus, animal activity is sufficient to produce the bare zone.

There is a characteristic bare zone adjacent to many shrubs that are members of the California chaparral and coastal sage communities (*1*). This zone is particularly obvious where a stand of these shrubs is immediately adjacent to a grassland area. Previous studies have emphasized the role of volatile inhibitors of plant growth produced by the shrubs, particularly terpenes, as being the main factor in the production and maintenance of this zone (*2*). That cattle grazing and trails could be responsible for this zone (*3*) has been discounted by Muller and others (*4*). Although Muller and co-workers acknowledge that small mammals and birds may be involved in the maintenance of the bare zone, they consider that plant toxins are mandatory for production of a bare zone (*4, 5*).

I have examined whether animal activity alone could account for the bare zone. This possibility has been suggested by J. R. Rood for a thorn bush association in Argentina. He states that the bare zone adjacent to the plants *Schinus fasciculatus* and *Cordalia microphylla* is caused by the hystricomorph rodent *Microcavia australis* (*6*).

In California the chaparral and coastal sage shrubs form excellent cover for rodents, rabbits, and birds. The adjacent grassland provides poor cover for most of these animals yet furnishes an excellent food supply for grazers and seed eaters. One would expect then that feeding activity of these small animals would be concentrated in grassland areas immediately adjacent to stands of shrubs. To see if increased

animal activity could account for the bare zone, I estimated feeding activity adjacent to these shrubs and determined if feeding activity was sufficient to account for the bare zone.

Studies of the bare zone adjacent to shrubs of *Salvia leucophylla* were carried out at the northern end of Malibu canyon, Los Angeles County, California; studies of the bare zone adjacent to assemblages of *Adenostoma fasciculatum*, *Artemisia californica*, and *Baccharis pilularis* were carried out on the Stanford University Jasper Ridge Biological Experimental Area, San Mateo County, California.

I established feeding stations adjacent to stands of *Adenostoma fasciculatum*, *Artemisia californica*, and *Salvia leucophylla*. At each station approximately 100 millet seeds were placed on a sheet of sandpaper (7) used to keep the seeds from rolling away. Fifty stations were placed in the bare zone and 50 in the grassland approximately 2 m beyond the edge of the bare zone. Twenty-four hours later each station was scored for seed removal. Usually either all or none of the seeds would be removed. Of the stations in the bare zone 86 percent had seeds removed; of the stations in the grassland only 12 percent had seeds removed.

During 24 hours, seeds could be removed by nocturnal and diurnal animals. During the day seeds are probably taken by birds; during the night seeds are probably taken by rodents. To test whether there was both nocturnal and diurnal foraging for seeds, I counted seeds at four stations in the bare zone around *S. leucophylla* and at four stations in the adjacent grassland at dawn and dusk for 4 days in May 1968. Initially 25 seeds were placed at each station. At each census the number of seeds was counted, and seeds that had been removed were replaced. The percentages of seed removed during the day and night, respectively, were 31.5 and 64.0 from the bare zone and 13.0 and 7.8 from the grassland.

To examine the distribution of mouse activity, I placed 75 live traps in the bare zone and 75 in the grassland about 2 m beyond the grassland border. The trapping was done in the spring of 1968 and 1970, and in the fall of 1969, in areas adjacent to *Adenostoma fasciculatum*, *Artemisia californica*, and *S. leucophylla*. Twenty-eight mice were trapped in the bare zone (26 *Peromyscus* and 2 *Reithrodontomys*), whereas only 1 (*Microtus*

Table 1. Dry weight of plant material in exclosures placed in the bare zone adjacent to *Baccharis pilularis* (mean and standard error; sample size of five), and in exclosures placed in the bare zone adjacent to *Salvia leucophylla* (mean with a sample size of two).

Bare zone of	Dry weight of plants (g)	
	Open-sided exclosures	Complete exclosures
B. pilularis	0.79 ± 0.17	15.04 ± 1.92
S. leucophylla	.50	11.62

californicus) was trapped in the adjacent grassland (near *S. leucophylla*).

To determine the activity of brush rabbits (*Sylvilagus bachmani*) and cottontail rabbits (*S. auduboni*), which commonly feed on the few grasses and forbs that remain in the bare zone and also on the grassland borders of the bare zone, I determined the distribution of rabbit feces adjacent to several different stands of shrubs. For each stand a series of ten 1-foot-wide transects was made from the edge of the shrubs into the grassland. For each transect the number of rabbit fecal pellets within each 1-foot interval was counted (Fig. 1). These sets of transects were made where there was an abrupt and straight edge between the two communities and where the grasslands continued beyond the stand of shrubs for at least 50 m. Rabbit fecal pellets were concentrated near the shrubs; no feces were found more than 7 feet into the grassland
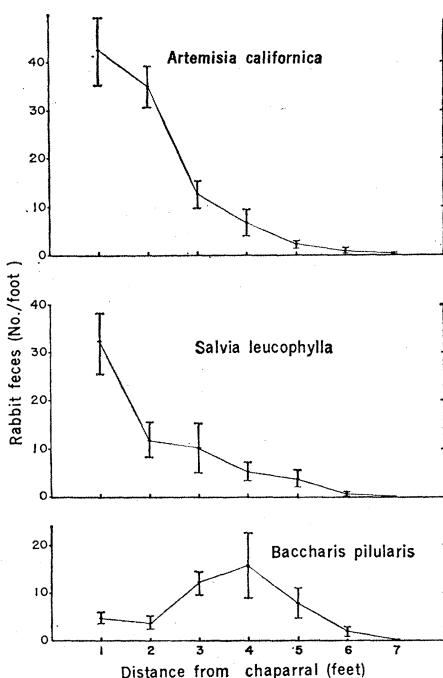

Fig. 1. Mean and standard error for the distribution of rabbit feces at 1-foot intervals between the edges of three stands of shrubs and the adjacent grassland.

(Fig. 1). The low density of feces in the first two intervals from *B. pilularis* may be due to the extreme bareness of these intervals and to the fact that as a result rabbits spend very little time feeding close to the shrubs. Transects made where there was not an abrupt straight edge between the two communities, or where there were small stands of shrubs in the grassland, showed an attenuation of the distribution of rabbit feces. For example, with one set of transects, made adjacent to a stand of *Adenostoma fasciculatum* in the fall of 1968, the density of feces did not decrease to zero until 20 feet beyond the shrubs. The more broken border probably allows the rabbits to venture farther into the grassland with safety.

My tests show that there is increased animal activity adjacent to members of the chaparral and coastal sage communities, but they do not indicate whether there is sufficient animal activity to produce or maintain the bare zone. In order to test this possibility, exclosures were set up to exclude animal activity from the bare zone (made of ¼-inch hardware cloth and measuring 1 foot square and 6 inches high). One type was closed on all sides so that no birds, rodents, or rabbits could enter; the other had a top and bottom, but was open on all four sides except for a column at each of the four corners. The use of partial and complete exclosures permitted differentiation between such factors as shading or dew condensation, and the foraging of vertebrates. The exclosures were set out in April 1969, and in April 1970 the plant material that had grown in the exclosures was collected, dried, and weighed.

Five one-sided and five complete exclosures were placed in the bare zone adjacent to a stand of *B. pilularis*. Also, two open-sided exclosures were placed in the nearby grassland about 10 m from these shrubs. Two open-sided and two complete exclosures were placed in the bare zone adjacent to *S. leucophylla*. There was a significant difference between the weight of plant material collected from the complete exclosures and that of material collected from the open-sided exclosures (Table 1). In the grassland the open-sided exclosures contained 18.21 and 13.38 g (dry weight) of plant material. The average of these two exclosures is not significantly different from that for the complete exclosures in the nearby bare zone.

One of the complete exclosures in

the bare zone of *S. leucophylla* contained only 5.26 g (dry weight) of plant material. Although this is an order of magnitude greater than the amount in either of the open-sided exclosures, this complete exclosure had less plant material than any of the other complete exclosures. This difference possibly results from this exclosure's being on a slope (whereas all the others were on level ground), the soil of which was undergoing sheet erosion. Consequently there would be fewer seeds under the exclosure for germination during the experiment.

Animal activity can possibly account for several characteristics of the bare zone. Outside the bare areas there is a region of partial inhibition of plant growth, which could be caused by volatile toxins (8). However, partial inhibition could also be caused by a decreasing gradient of grazing activity (Fig. 1). If an annual plant is repeatedly grazed, it may become stunted as the drought season progresses and water becomes limiting for growth. Also, although the annual may continue to produce a flowering stalk, it will lack some of the storage products that are available to an ungrazed plant.

Another characteristic of the bare zone is the prevalence of native perennial grasses (9). It has been suggested that adult plants are inhibited to a lesser extent than seedlings (9). Thus, if a perennial grass becomes established in the bare zone, it would not be as inhibited by volatile toxins as would annual grasses which must be reestablished every year. However, animal activity can also account for the maintenance of perennial grasses in the bare zone. These grasses need not reproduce by means of seeds every year, but can continue to produce tillers. Thus, seed foraging will not affect these grasses to the same extent as annual grasses. These perennial grasses are often cropped, probably by rabbits, but the grasses seem to be able to withstand this cropping. Another characteristic of the bare zone is the occurrence of seedlings of adjacent shrubs (10). These plants have secondary plant products, such as terpenes, phenols, and cyanide (9), which would decrease their palatability to herbivores. Therefore, they can become established in the bare zone while more edible plants cannot. Several authors have discussed the selective value of these secondary plant products as means of protection against herbivores (11).

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Muller and co-workers have demonstrated that volatile toxins produced by some of the coastal sage and chaparral plants are toxic to germinating seedlings, and terpenes can be absorbed by lipids and adsorbed on soil particles (8). However, in these studies much higher concentrations have been used than are found under field conditions, and it has yet to be shown that volatile inhibitors of plant growth are present in sufficient concentrations to cause the bare zone under field conditions.

Neither *B. pilularis* (12) nor *A. fasciculatum* (10, 13) has been shown to contain volatile plant growth inhibitors, yet stands of both of these shrubs often have well-developed bare zones. *Adenostoma fasciculatum* contains water-soluble toxins, and it has been proposed that these chemicals cause the lack of annuals directly under shrubs of *A. fasciculatum* (10, 13).

The extent of the relative contribution of chemical and animal inhibition to the formation and maintenance of the bare zone needs further investigation. However, annuals will grow in the bare zone with either the presence or absence of volatile toxins if animal activity is excluded.

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Parkinson's Disease: Activity of L-Dopa Decarboxylase in Discrete Brain Regions

Abstract. *The activity of* L-dopa *decarboxylase was greatly reduced in the striatum, less so in the hypothalamus, and unchanged in the cortex of brains of patients with Parkinson's disease. However, it appears that even in the striatum enough activity remained to allow for the formation of dopamine from* L-dopa *in patients treated with large doses of* L-dopa.

Although the symptomatology of Parkinson's disease has been known for a long time, it was not until about 10 years ago that insight was obtained into the neurochemistry of this disease. Dopamine (3,4-dihydroxyphenylethylamine) has a characteristic distribution pattern within the mammalian brain; 80 percent of the total dopamine in the brain occurs in the subcortical extrapyramidal regions, notably the caudate nucleus, putamen, substantia nigra, and globus pallidus (1). In patients with Parkinson's disease the concentrations of dopamine (2) and its major metabolite homovanillic acid

(3) in these regions of the brain are greatly decreased, most probably as a result of degeneration of the nigrostriatal dopaminergic neurons (4). The importance of the dopamine deficiency in the brains of patients with Parkinson's disease has resulted in the successful clinical application of L-3,4-dihydroxyphenylalanine (L-dopa), dopamine's immediate precursor, in the treatment of this disease (5).

The enzyme converting L-dopa to dopamine is L-dopa decarboxylase (E.C. 4.1.1.26) (6). We described a sensitive assay for the determination of L-dopa decarboxylase in autopsy