globulin class, and that generalizations derived from a study of κ, λ, and γ chains may not extend to comparisons of other immunoglobulin polypeptide chains.

RICHARD L. WASSERMAN
J. DONALD CAPRA
Department of Microbiology, University of Texas Health Science Center at Dallas, Dallas 75235

References and Notes

1. J. A. Gally, in *The Antigens*, M. Sela, Ed. (Academic Press, New York, 1973), vol. 1, pp. 162–285.
2. R. T. Kubo, B. Zimmerman, H. M. Grey, in *ibid.*, pp. 417–471.
3. J. Novothý, D. Dolejŝ, F. Franêk, *Eur. J. Biochem.* **31**, 277 (1972).
4. J. D. Capra, in *Antibodies in Human Diagnosis and Therapy*, E. Haber and R. M. Krause, Eds. (Raven, New York, 1977), pp. 87–102.
5. J. D. Capra, R. L. Wasserman, J. M. Kehoe, *J. Exp. Med.* **138**, 410 (1973).
6. J. D. Capra, in *The Generation of Antibody Diversity: A New Look*, A. J. Cunningham, Ed. (Academic Press, New York, 1976), pp. 65–87.
7. J. J. Marchalonis, *Nature (London), New Biol.* **236**, 84 (1972).
8. J. D. Capra and A. Hurvitz, *J. Immunol.* **105**, 949 (1970).
9. R. L. Wasserman and J. D. Capra, *Biochemistry* **16**, 3160 (1977).
10. D. W. Klapper, C. E. Wilde III, J. D. Capra, *Anal. Biochem.*, in press.
11. F. W. Putnam, G. Florent, C. Paul, T. Shinoda, A. Shimizu, *Science* **182**, 287 (1973).
12. S. Watanabe, H. U. Barnikol, J. Horn, J. Bertram, N. Hilschmann, *Z. Physiol. Chem.* **354**, 1505 (1973).
13. In the sequence comparisons, whenever the two human proteins differ in an amino acid assignment and the canine protein agrees with one of the assignments, the assumption has been made, for discussion purposes only, that the cause of disparity between the human sequences is of technical orgin. For example, positions 386 to 8 were found to be Glu-Asn-Gly in the canine protein as well as in Ou. It is possible that the assignment Asp-Gly-Glu in the Gal protein represents a technical transposition. Similarly the deletion at position 373 and the insertion required between positions 488 to 489 may also be technical.
14. C. Chuang, J. D. Capra, J. M. Kehoe, *Nature (London)* **244**, 158 (1973).
15. Supported in part by NIH grants AI-12127, AI-12796, and AI-14742 and NSF grant PCM 76-22411. R.L.W. was supportd by Cancer Immunology training program grant CA09082. We thank Dr. Charles E. Wilde III for his review of the manuscript and Dr. A. Hurwitz for plasma.

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Disturbance and the Dispersal of Fleshy Fruits

Abstract. *Fruits of* Prunus serotina, Phytolacca americana, *and* Vitis vulpina *were placed during separate trials in forest sites that varied in the degree to which the forest canopy was disturbed. Removal rates of fruits were consistently faster in the forest edge and light gap sites than in sites under closed canopy. Rapid removal of fruits from species that ripen fruit in summer and early fall is selectively advantageous to the plants because it minimizes the probability that fruits will be destroyed by invertebrates before dispersal. Disturbances probably play an important role in interactions between temperate fruits and birds and in community organization.*

Interactions between animals and plants are patchy in their occurrence. That is, individuals in certain locations in any plant population are more likely to be attacked by herbivores, to be visited by pollinators, or to have their seeds dispersed by animals than are plants in other locations in that population. Identification of the conditions under which these interactions are most likely to occur provides a basis for understanding the role played by interactions between animals and plants in generating or maintaining patchiness in communities.

The eastern deciduous forest of North America has been and is now a patchwork of stands that differ in age and structure (*1*). Small light gaps caused by treefalls and forest edges created by larger disturbances such as fire, tornadoes, or human activity interrupt areas of unbroken canopy. Although recent work has begun to unravel the role of disturbance in organizing the plant communities of temperate forests (*1*), little experimental work has been done on how this mosaic of patches affects interactions between animals and plants (*2*). Many forest plants rely on animals for both pollination of flowers and dispersal of seeds. The purpose of our study was to evaluate the effect of this mosaic of patches on the probability of dispersal of fleshy fruits.

Many of the major avian frugivores either spend most of the year in areas with a well-developed shrub and vine layer (catbirds, brown thrashers) (*3*), or spend more time in such habitat types during late summer and early fall when most fruits are ripening than during spring and early summer (red-eyed vireos, some thrush species) (*4*). On the basis of these considerations, we hypothesized that fleshy fruits in light gaps and along forest edges have a greater probability of dispersal as compared to fruits under the closed forest canopy.

Experiments were conducted in Trelease Woods, a 22.4-ha preserve dominated by sugar maple (*Acer saccharum*) and located northeast of Urbana, Illinois. Sixty sites were chosen in three types of habitat. Under the closed canopy, 20 sites 50 m apart were distributed along two transects through the middle of the forest. Twenty sites were also chosen along the forest edge, each separated by 100 m, with five sites on each of the four sides of the woods. Finally, 20 sites were chosen within light gaps in the forest (except for *Prunus* trial 1 in which only ten sites were used). All light gaps were 4 to 8 m in diameter and had a dense layer of vines.

An infructescence with a known number of fruits was taped to a branch of a shrub or tree about 2 m above the ground. The number of fruits per infructescence was the same for all sites on any one trial but varied between six and ten fruits between trials. The experiment was repeated five times between 31 July and 28 September 1977. This is the period over which most plants with fleshy fruits ripen in central Illinois. The experiment was performed twice with wild black cherry (*Prunus serotina*), twice with pokeweed (*Phytolacca americana*), and once with frost grape (*Vitis vulpina*).

These three species were chosen because of accessibility and morphological characteristics that made them easy to attach as multifruited units. Each trial lasted 7 days. The number of fruits remaining at each site, and the presence or absence of invertebrate damage was recorded daily. The ground beneath fruits was also checked daily for any fruits that may have fallen. The few fruits (< 1 percent) that did fall during the five trials were not counted as having been removed.

Fruits were removed at a significantly (*5*) faster rate from both the edge and light gap sites than from the sites under closed canopy (Fig. 1a). Only in the second *Prunus* trial did the rate of fruit removal from the edge sites not differ significantly from that under the closed canopy. Heavy thunderstorms over several days of this trial caused birds to move from the forest edge to the interior. During this trial, however, fruit removal within light gaps remained faster than under closed canopy as in all other trials. Whether edge or light gap sites had the faster removal rate varied between trials.

These differences in removal rates among habitat types have two components: (i) the rate at which sites were discovered (*6*), and (ii) the rate at which fruits are removed once sites were discovered. A significantly ($P < .05$) larger percentage of the sites under closed canopy as compared to both the edge and light gap sites remained undiscovered for a longer period of time (Fig. 1b). This suggested that sites resulting in rapid dis-

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persal of fruits were fewer under closed canopy. Again the exception was the second *Prunus* trial in which the edge sites were discovered at a significantly slower rate than the light gap and interior sites were. There was no consistent pattern in the rate at which the mean number of remaining fruits approached zero if the undiscovered sites were excluded from the analysis. In two of the trials the rates were significantly slower for the closed canopy sites. In the other three trials, there were no significant differences between edge and closed canopy sites. However, in two of these trials rates of removal in light gaps were significantly higher than they were in either edge or closed canopy sites. Therefore, much of the difference in removal rates between habitat types resulted from differences in the rates at which sites were discovered. In some trials this was augmented by faster removal rates from sites once discovered.

Table 1. Mean abundance of individuals (± the standard deviation) of major frugivores (thrushes, mimids, red-eyed vireos) along the census route in the study area during each of the five trials. The number of censuses are those made along the same census route during the trial. Fewer censuses were taken during the earlier trials because of low variability in bird abundance during summer.

Trial	Dates of trial	Mean ± S.D.	Censuses (No.)
Prunus 1	31 July to 7 August	6 ±	1
Prunus 2	8 August to 15 August	8.0 ± 0.0	2
Phytolacca 1	30 August to 6 September	22.0 ± 9.97	4
Phytolacca 2	8 September to 15 September	24.3 ± 12.0	3
Vitis	21 September to 28 September	6.3 ± 1.48	4

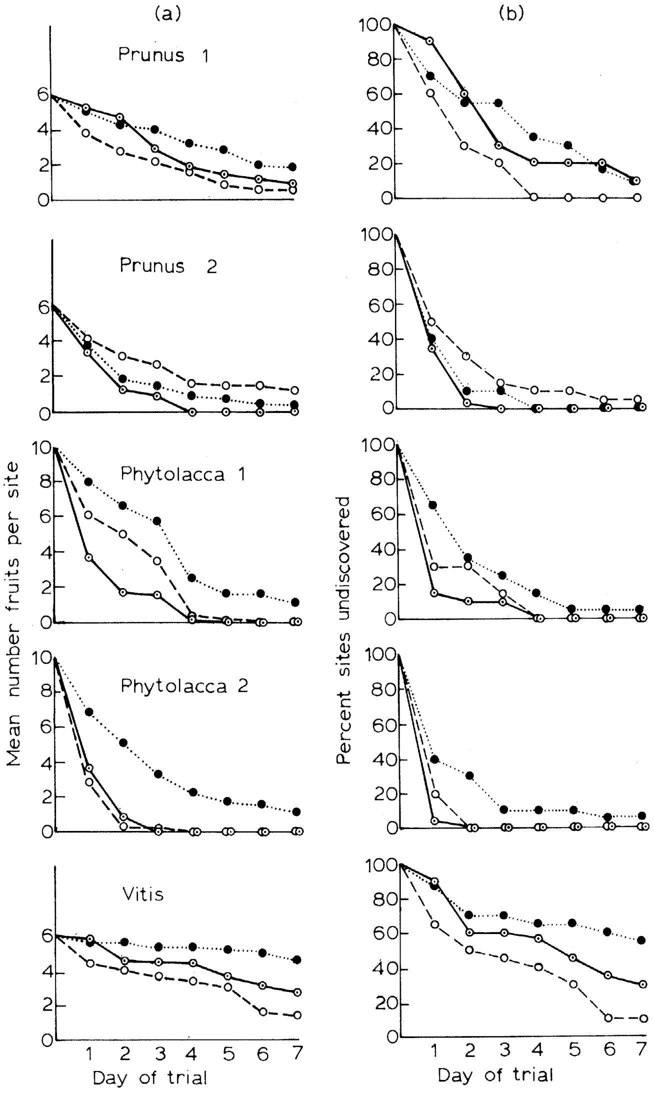

Fig. 1. (a) Mean number of fruits remaining in sites under closed forest canopy (●), in light gaps (⊙), and along the forest edge (○) on days 1 to 7 after placement of fruit. (b) Percentage of sites under unbroken forest canopy, in light gaps, and along the forest edge yet to be discovered by frugivores on days 1 to 7 after placement of fruit.

Rates of site discovery and fruit removal varied among trials (Fig. 1). Handling of these fruits and preferences by the birds differ (*7*). More important, abundance of avian frugivores varied greatly over this time period (Table 1). Both frugivore abundance and removal rates of fruits were lowest during the first *Prunus* and the *Vitis* trials. Despite these differences in fruit and in avian frugivore abundance, the relative pattern of removal rates remained the same throughout the trials.

If we assume that dispersal enhances offspring survival (*8*), there is a selective advantage for a plant fruiting in summer or early fall to have its fruits removed quickly after ripening. Invertebrate attack on fruits increased with time during the first four trials. Various species of ants, especially, and harvestman (phalangids) ate the pulp of both *Prunus* and *Phytolacca*, sometimes leaving only the seeds. From the sum of the first four trials, the percentages of sites that had some fruits showing invertebrate damage on days 3, 5, and 7 were 11 percent (11/102), 20 percent (10/50), and 62 percent (21/34), respectively. The *Vitis* trial was late in the season, and these fruits suffered no invertebrate damage. Hence, except for late fruiting species, the longer a plant must wait to have its fruits dispersed after ripening, the greater the probability that the fruits will be destroyed by invertebrates before they are dispersed. Some species that fruit in late fall have fruits that remain on the plants well into winter and are removed by winter frugivores at erratic intervals. Low probability of invertebrate damage may permit this alternative strategy (*7*).

Each of the plant species used in these trials commonly fruits in forest light gaps and along forest edges. Our results, however, appear to be generally applicable for forest understory plants with fleshy fruits. In comparisons among a number of plant species over 3 years, removal of fruits from spicebush (*Lindera benzoin*), a species that often fruits under closed canopy, were slower than rates for most forest edge and light gap species that fruited at the same time (*7*). Also, removal rates of fruits from the forest herb *Smilacina racemosa* are faster in forest edge sites than under closed canopy (*7*). Therefore, even for species that often grow under closed canopy, individuals growing in the light gaps may contribute a disproportionate number of offspring to future generations. If this is so, then plants under closed canopy should spend more energy in maintenance and vegetative propagation and less on fruit production than individuals in light gaps or edges. Although there is some evidence that fruit production sometimes differs between individuals in light gaps and conspecifics under closed canopy (*9*), the evolutionary basis for these differences is not yet clear.

The evolutionary basis for faster removal of fruits from light gap and edge sites remains speculative. It is doubtful that either the birds or the fruits act only as independent variables in this interaction to which the other must adjust. A disproportionate number of plant species that fruit in light gaps have brightly colored fleshy fruits in comparison to plant species that generally fruit under closed forest canopy. Brightly colored fruits may be discovered more readily in sunlit patches than under closed canopy. The attraction of frugivores to these sites may be enhanced by their learning that such sites potentially offer a concentration of fruit. Hence, concentration of fruits and frugivores in light gaps and edges may be continually reinforced in ecological and evolutionary time.

These results also emphasize that disturbances play an important role not only in interactions between temperate fruits and birds themselves, but also in the organization of temperate forest communities. In ecology "equilibrium"-thinking has clouded the potential importance of small- and large-scale disturbances in the organization of biological communities. Investigations in a number of terrestrial and aquatic systems have begun to reveal the widespread importance of disturbance in the normal organization of communities (*1*, *10*). The disturbance regime in a community affects the pattern of spatial heterogeneity, the life history adaptations of the species, and the resultant relative abundances of species. In many coniferous and deciduous forests of North America, small-scale disturbances occur on a given patch of landscape every 5 to 250 years, depending on the type of forest and its location (*1*). Large-scale disturbances in some areas occur at longer intervals. We need to know how much the life history strategies of temperate forest plants and animals are responses to disturbance as compared to steady-state conditions if we are to understand how these communities are organized.

JOHN N. THOMPSON
*Department of Entomology,
University of Illinois, Urbana 61801*
MARY F. WILLSON
*Department of Ecology, Ethology,
and Evolution, University of Illinois,
Champaign 61820*

References and Notes

A. N. Auclair, and G. Cottam, *Ecol. Monogr.* **41**, 153 (1971); J. D. Henry and J. M. A. Swan, *Ecology* **55**, 772 (1974); H. S. Horn, in *Theoretical Ecology: Principles and Applications*, R. M. May, Ed. (Saunders, Philadelphia, 1976), p. 187; P. J. Grubb, *Biol. Rev.* **52**, 107 (1977); T. T. Kozlowski and C. E. Ahlgren, Eds. *Fire and Ecosystems* (Academic Press, New York. 1974); C. G. Lorimer, *Ecology* **58**, 139 (19 P. L. Marks, *Ecol. Monogr.* **44**, 73 (1974); C. D. Oliver and E. P. Stephens, *Ecology* **58**, 562 (1977); S. T. A. Pickett, and J. N. Thompson, *Biol. Conserv.* **13**, 27 (1978); G. B. Williamson, *Ecology* **56**, 727 (1975).

2. But see, A. J. Smith, *Ecology* **56**, 19 (1975).
3. A. C. Bent, *U.S. Natl. Mus. Bull.* **195**, 1 (1948); R. R. Graber, J. W. Graber, E. L. Kirk, *Ill. Nat. Hist. Surv. Biol. Notes No. 68* (1970).
4. J. R. Carpenter, *Ecology* **16**, 203 (19 A. C. Twomey, *Ecol. Monogr.* **15**, 173 (1945); A. C. Bent, *U.S. Nat. Mus. Bull.* **196**, 1 (1949); R. R. Graber, J. W. Graber, E. L. Kirk, *Ill. Nat. Hist. Surv. Biol. Notes No. 75* (19 P. Williamson, *Ecol. Monogr.* **41**, 129 (1971).
5. Throughout, differences in rates were tested with analysis of covariance using $\log_{10}$ and arc sin transformations where necessary to correct for heteroscedasticity and nonlinearity of regression lines.
6. Discovery is used here loosely. We do not yet know whether certain sites from which no fruit has been removed have not been found by the birds, or whether the sites are being avoided for other reasons even though the birds know fruit is present.
7. J. N. Thompson and M. F. Willson, in preparation.
8. It is reasonable to assume that, if a plant invests energy in making fleshy fruits to be taken by dispersal agents, there is a selective advantage in having seeds dispersed.

L. K. Halls and R. Alconiz, *J. Wildl. Manage.* **32**, 185 (1968); L. K. Halls, *U.S. For. Serv. Res. Pap. SE No. 90* (1973); I. V. Hall, and J. D. Sibley, *Can. J. Plant Sci.* **56**, 885 (1976).

P. K. Dayton, *Ecol. Mongr.* **41**, 351 (1971); M. L. Heinsel, *U.S. For. Serv. Pac. Northwest For. Range Exp. Stn. Res. Notes* (1971), pp. 61– J. R. Karr, *Ecol. Monogr.* **46**, 457 (1976); S. A. Levin, *Annu. Rev. Ecol. Syst.* **7**, 287 (1976)); S. T. A. Pickett, *Am. Nat.* **110**, 107 (1976); P. J. Regal, *Science* **197**, 622 (1977); P. F. Sale, *Am. Nat.* **111**, 337 (1977), J. A. Wiens, *Annu. Rev. Ecol. Syst.* **7**, 31 (1976); *Am. Sci.* **65**, 590 (1977).

11. We thank F. A. Bazzaz, G. Brown, R. Condit, D. H. Janzen, J. R. Karr, S. T. A. Pickett, J. F. Thompson and an anonymous reviewer for comments on an earlier draft. Supported in part by a grant-in-aid of research from Sigma Xi.

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Absence of Adenosine Deaminase Activity in a Mammalian Cell Line Transformed by Rous Sarcoma Virus

Abstract. *No detectable adenosine deaminase activity was found in whole cells or 105,000*g *cytosol preparations of B-mix K-44/6 cells when either [^{3}H]adenosine or [^{3}H]arabinosyladenine was used as substrate. When grown in tissue culture medium supplemented with horse serum these cells provide a deaminase-free system not requiring the use of an adenosine deaminase inhibitor.*

Adenosine deaminase (adenosine aminohydrolase, E.C. 3.5.4.4) has a very wide distribution in animal tissues and has been studied extensively [see (*1*)]. In addition to adenosine, the enzyme accepts a wide variety of adenine nucleosides as substrates, including deoxyadenosine and arabinosyladenine (ara-A) (*2*). Multiple forms of adenosine deaminase may be found even within a single tissue, and the patterns of inheritance of its isoenzymes have been studied (*3*). The enzyme participates in the catabolism of adenine nucleosides, resulting in the production of hypoxanthine for use in purine salvage pathways. In the heart, this enzyme may serve an important regulatory function by inactivating adenosine, a potent vasodilator (*4*). A deficiency of adenosine deaminase has been associated with severe combined immunodeficiency disease (SCID) in children (*5*), but a well-defined causal relationship has not been established (*6*). Residual adenosine deaminase activity has been detected in the fibroblasts derived from patients with SCID and adenosine deaminase deficiency (*7*).

Studies in vitro on the mode of action of the antiviral drug ara-A are complicated by the deamination of ara-A to arabinosylhypoxanthine (ara-H) by adenosine deaminase (*8*). Although the adenosine deaminase activity associated with the serum normally used to supplement tissue culture media can be minimized by prolonged thermal inactivation (*9*), or through the use of a variety of adenosine deaminase inhibitors (*10*), a cell line devoid of adenosine deaminase activity has not been described. We describe in this report an established line of mammalian cells (B-mix K-44/6) totally lacking detectable adenosine deaminase activity. The B-mix K-44/6 cells were subcloned from a population of embryonic rat cells transformed in vitro by the Prague strain of Rous sarcoma virus (*11*). These large epithelioid cells are malignant for homologous rat hosts and have been shown both by experiments in vivo (*11*) and by cell fusion studies with chick-embryo fibroblasts (*12*) to contain the genome of Rous sarcoma virus. In our laboratory B-mix K-44/6 cells have proved useful in elucidating the effects of ara-A on macromolecular biosynthesis in a cell system not requiring the use of an inhibitor of adenosine deaminase (*13*).

In this study we used, in addition to B-mix K-44/6 cells, an established line of human cells derived from an epidermoid carcinoma of the mouth (KB) and a continuous line of baby hamster kidney cells

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