Table 1. Absorption (18 Mcy/sec), February 1958, 1200 local time.

| Date | 9 | 10 | 11 | 12 | 13 |
|---|---|---|---|---|---|
| Absorption (neper) | 0.9 | 0.9 | 0.2 | 0.7 | 0.9 |
| fOF2 (Mcy/sec) (San Francisco values) | 14.1 | 14.2 | 4.7 | 11.4 | 13.2 |

U.T. and 0727 U.T., and between 0847 U.T. and 1025 U.T. Unfortunately, an automatic calibration interrupted the record from the vertical beam at midnight, local time (0700 U.T.).

Note the detailed correspondence of fluctuations in intensity on the two total power records. Since the antenna beams intersected the ionosphere at points located 150 or more kilometers apart over the surface of the earth, we conclude that the ionization produced by the aurora was essentially uniform over that region. Little and Leinbach (*1*) drew a similar conclusion for auroral zone absorption.

The presence of phase power, on the other hand, suggests a variation in absorption within the antenna beams of the interferometer. This conclusion is consistant with the previous conclusion on the uniformity of ionization since the phase power amounts to a small fraction (at most 30 percent, and usually much less) of the total power in the Ryle interferometer.

Curiously, the sign of the phase power remained constant throughout the aurora, as though we were dealing with a single patch of ionization that remained constant in position between two of the interference fringes. If we assume that the maximum amplitude of the phase power, in units of the total power in the interferometer, corresponds to a complete absorption of the cosmic noise over a limited cloud-like region of ionization, we may estimate the size and location of the cloud. The total beam of the corner reflectors used in the interferometer subtends roughly 2000 square degrees on the sky. Thirty percent of this area amounts to a region roughly 25 by 25 deg. The fringes of our interferometer are, in the zenith, spaced much more closely than 25 deg, and only yield spacing of as much as 10 deg near the northeast horizon. A cloud 10 by 60 deg, elongated parallel to the fringes in the low northeastern part of our pattern, explains satisfactorily all aspects of the phase power record. Finally, such a cloud corresponds quite closely to the optical phenomenon known as a quiet arc.

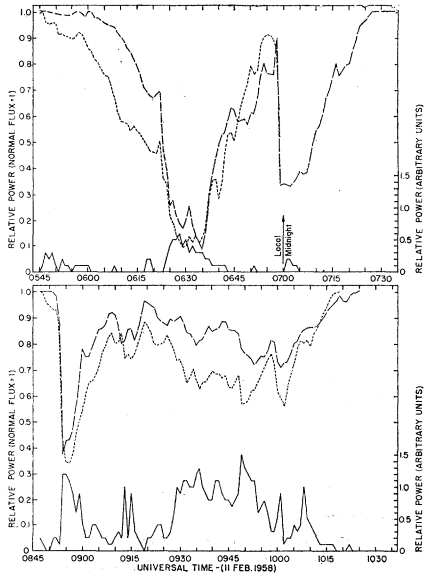


Fig. 1. Dashed line, total power in the interferometer system; broken line, power in the vertical beam (read values on the left-hand scale, normalized so that the unit is power level outside of the aurora); solid line, phase power (of constant sign) in the Ryle interferometer (read values from the right-hand scale, normalized so that the unit is 0.05 times the normal total power level).

Since the fluctuations in the amplitude of the phase power corresponded quite closely to the fluctuations appearing on the two total power records, our conclusion is that increases in the intensity of ionization in the auroral arc on 11 February 1958 strongly correlate with corresponding increases in the intensity of the ionization hundreds of kilometers away, overhead in Boulder, Colorado.

This equipment ran continuously throughout the preceding and following days. We have computed the noontime absorption (local noon is 1900 U.T.), by comparing the vertical beam records with midnight records from 6 months previously. Since the noontime fOF2 values are so high, we also corrected for an ionospheric cutoff effect of 0.13 neper, for fOF2 values of 14 Mcy/sec. The absorptions, along with the corresponding fOF2 values, appear in Table 1. The absorption was lower by 0.7 neper on 11 February, the day after the aurora, and only recovered to the normal level on the 13th.

The interferometer had been aimed toward the northeast, not to observe auroral effects, but to observe the rising of the bright discrete radio noise source, Cygnus A. Over the preceding and following days, we had found a normal pattern of rising, in which the source disappears from view between 0800 and 0900, local time. On 11 February, in contrast, the source continued to be visible until, late in the morning, it passed out of the antenna beam. This observation confirms the low value of electron density in the F-regions on that day.

Two possible explanations for the lowered absorption may be mentioned. We assume that the value 0.7 neper is the absorption normally produced by the F-region when fOF2 is 14 Mcy/sec. We extrapolate the curve, fOF2 as a function of F2 region absorption, derived by Mitra and Shain (*2*), to this critical frequency, and find only 0.5 neper. Our higher value suggests that Mitra and Shain's curve steepens at high frequencies. Our first explanation is therefore that we are dealing entirely with F2 region absorption and that the F2 layer was missing (for unspecified reasons) on 11 February. However, this interpretation runs into minor difficulty on 12 February. Again, extrapolating the curve of Mitra and Shain, we predict 0.3 neper in comparison with the observed 0.5 neper, still a discrepancy of 0.2 neper. This implies that instead of an error in extrapolation we have a scale error applying to the entire curve of absorption as a function of fOF2.

Suppose that a major part of the absorption on 9 and 10 February took place in the D-region. Our second explanation postulates that the intense aurora destroyed the ionizable constituent, NO, in the D-region. The lowered absorption then corresponds to a recovery of the D-region to its normal chemical state.

The statistics of diurnal absorption allow a means of testing these hypotheses. Decreases in fOF2 associated with magnetic storms are independent of the sun's ionizing radiation. The diurnal absorption should be constant throughout such decreases, if it is essentially a D-layer effect.

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**References and Notes**

1. C. G. Little and H. Leinbach, *Proc. I.R.E. Inst. Radio Engrs.* 46, 334 (1958).
2. A. P. Mitra and C. A. Shain, *J. Atmospheric and Terrest. Phys.* 4, 204 (1953).
3. This research was supported by the Electronics Research Directorate, Air Force Cambridge Research Center. Ans Pottasch and Robert H. Lee participated in the program leading to these results.

17 March 1958

## Burnsi and Kandiyohi Genes in the Leopard Frog Rana pipiens

Two pattern variants of the leopard frog, *Rana pipiens,* have been found in populations from midwestern United States, particularly Minnesota (*1, 2*). A burnsi or nonspotted variety was demonstrated by Moore (*3*) to be a simple Mendelian dominant to the common

spotted (*pipiens*) pattern. A kandiyohi or mottled deviant was shown by Volpe (*4*) to be also a simple dominant mutant of the common spotted leopard frog. Subsequent breeding tests (*5*) revealed that the genes governing the expression of the three pigment patterns may be allelic, closely linked, or located at two different, independently assorting loci.

Results of breeding tests, reported here, obtained independently in two laboratories, indicate the existence of a fourth phenotype, designated "mottled burnsi." In crosses previously reported (*5*), Volpe failed to detect the mottled burnsi class.

The methods of experimentation employed in each laboratory were essentially the same as those used in earlier work (*3–5*). The notable modification in technique was that of rearing the offspring *beyond* metamorphosis, for a period ranging from several days to 6 months. Misjudgments are not likely to occur when phenotypic determinations are made on postmetamorphic juvenile frogs rather than on newly transformed frogs or on those possessing remnants of the tail [compare Fig. 1 with Fig. 17 in Volpe (*5*)].

In the experiment conducted by Anderson, the eggs of a single kandiyohi female were fertilized in two batches, the first with sperm of a common spotted (*pipiens*) frog, the second with sperm of a burnsi frog. The former cross yielded 91 kandiyohi and 111 *pipiens* offspring, or 1:1 ($p > 0.10$). The kandiyohi female was thus heterozygous for the mottling gene. The burnsi male proved to be heterozygous for the nonspotting gene (*6*). Four patterns (Fig. 1) were recovered from the cross, kandiyohi ♀ × burnsi ♂, the numbers and phenotypes being as follows: 40 kandiyohi, 36 burnsi, 39 *pipiens*, and 32 of the type designated "mottled burnsi." The mottled burnsi offspring combines characteristics of the two mutant forms; it lacks the large dorsal spots, as does the burnsi variant, and possesses the vermiculate mottling characteristic of the kandiyohi mutant. The segregating ratio is 1:1:1:1 ($p > 0.70$), not 2:1:1, as reported previously by Volpe (*5*). The error was due to the grouping of the two classes of mottled progeny, kandiyohi and mottled burnsi, into one phenotypic class.

Volpe repeated his earlier work with the view of raising the offspring to sexual maturity (*7*). Reciprocal crosses between the mutant types were performed. The experiment was rewarding only in revealing the mottled burnsi pattern, since none of the progeny survived to maturity (this was true in the case of crosses performed by Anderson also). The segregation observed in the progeny of the cross, kandiyohi ♀ × burnsi ♂, was 15 kandiyohi: 11 burnsi:10 *pipiens*:14 mottled burnsi.

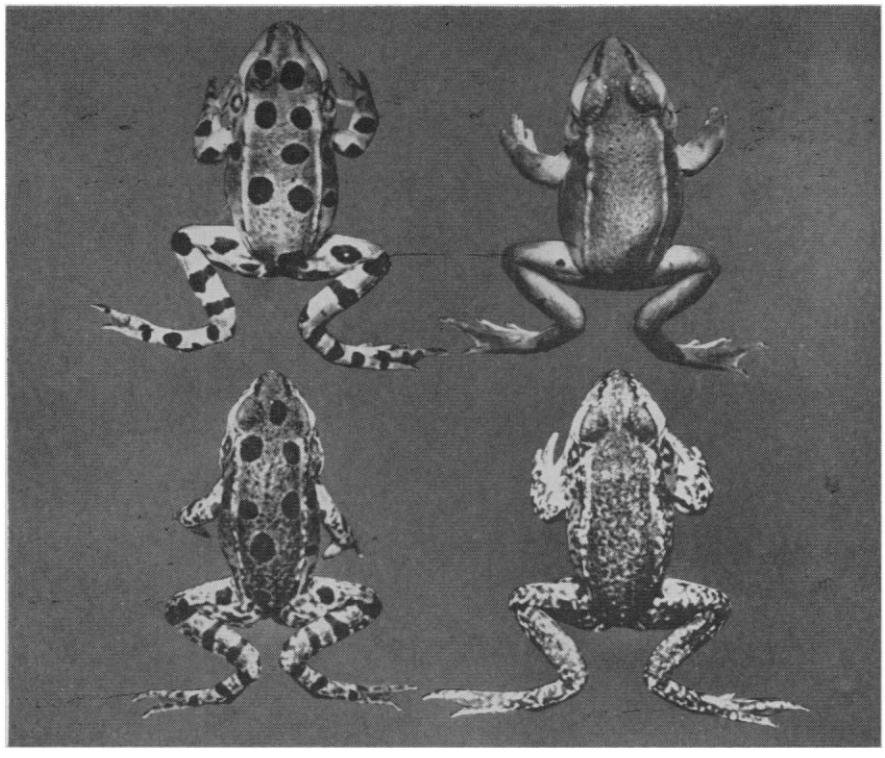

Fig. 1. Four patterns recovered in a ratio of 1:1:1:1 from a cross of a mottled (kandiyohi) with a nonspotted (burnsi) leopard frog. Offspring were as follows: common spotted or *pipiens* (upper left); nonspotted or burnsi (upper right); mottled or kandiyohi (lower left); and "mottled burnsi" (lower right).

The reciprocal cross, burnsi ♀ × kandiyohi ♂, yielded 10 kandiyohi, 7 burnsi, 8 *pipiens*, and 5 mottled burnsi. Neither of these ratios differs significantly from 1:1:1:1 ($p > 0.70$ in the former, $p > 0.50$ in the latter) (*8*). The results are interpretable on the basis that the parental kandiyohi and burnsi frogs in each cross were heterozygous.

Since experimentation beyond the $F_1$ still constitutes a challenge, the mode of inheritance of the pigment patterns remains problematical. The varieties may depend upon a series of multiple alleles (burnsi or nonspotted, $C^B$; kandiyohi or mottled, $C^K$; *pipiens* or common spotted, $c^+$). The heterozygous kandiyohi and burnsi parents in the afore-mentioned experiments would be $C^Kc^+$ and $C^Bc^+$, respectively; the mottled burnsi offspring thus would represent the compound, $C^KC^B$. The results can be explained equally well by assuming two pairs of alleles that assort independently or are completely linked. If we designate the kandiyohi gene *K*, burnsi, *B*, and *pipiens*, $K^+$ or $B^+$, the kandiyohi parent (in each of the above crosses) could have been either $KK^+B^+B^+$ (independent assortment) or $KB^+/K^+B^+$ (close linkage). Similarly, the burnsi parent could have been either $K^+K^+BB^+$ or $K^+B/K^+B^+$; the mottled burnsi offspring would be either $KK^+BB^+$ or $KB^+/K^+B$. Whichever of the three alternative inheritance schemes is correct, it is evident from the present data that the kandiyohi gene is neither dominant nor epistatic to the burnsi gene.

The recovery of mottled burnsi frogs in laboratory cultures raises the question of their existence in nature. The mottled burnsi frog apparently has escaped detection in natural populations or, if seen, has not been reported. Knowledge of the distribution and frequencies of the kandiyohi and burnsi mutants is incomplete; however, both variants are known to coexist in certain localities (*1, 9*). The kandiyohi and burnsi variants may be sufficiently rare as to preclude a chance meeting of the two. It may be that the mottled burnsi frogs, if produced in nature, are at a strong selective disadvantage. Population studies are in progress (*10*).

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### References and Notes

1. A. C. Weed, *Proc. Biol. Soc. Wash.* 35, 107 (1922); G. Swanson, *Copeia* 1935, No. 3, 152 (1935); W. J. Breckenridge, *Reptiles and Amphibians of Minnesota* (Univ. of Minnesota Press, Minneapolis, 1944).
2. The burnsi and kandiyohi mutants have been reported only from the midwestern area; however, the two mutant types are known to occur sporadically in Maine, Nevada, and Mexico (R. Ruibal and J. A. Moore, personal communication).

3. J. A. Moore, *Genetics* 27, 408 (1942).
4. E. P. Volpe, *Systematic Zool.* 4, 75 (1955).
5. ——, *J. Heredity* 47, 79 (1956).
6. All burnsi and kandiyohi adults utilized as parents in previous crosses (*3–5*) were also heterozygous. No homozygous adults of these mutant types have been uncovered in breeding tests.
7. This research was supported by a grant from the National Science Foundation (NSF-G3332).
8. We assume that there is no differential mortality among the larvae. In Anderson's kandiyohi ♀ × *pipiens* ♂ and kandiyohi ♀ × burnsi ♂ crosses, 28 percent (78 of 280) and 38 percent (92 of 239), respectively, of the larvae died prior to metamorphosis. In Volpe's kandiyohi ♀ × burnsi ♂ and burnsi ♀ × kandiyohi ♂ crosses, 33 percent (24 of 74) and 48 percent (28 of 58), respectively, of the tadpoles failed to transform.
9. Professional frog dealers in the midwest estimate (a rough approximation at best) that the kandiyohi and burnsi variants each comprise 1 percent of leopard frog populations (*3–5*).
10. D. J. Merrell at the University of Minnesota is presently engaged in a study of the mutant populations in the Minnesota-Dakotas area (personal communication).

19 December 1957

## Apparent Movement of Southern Bean Mosaic Virus across Steamed Areas of Bean Stems

In 1933 Grainger (*1*) reported that tobacco mosaic virus moved across steamed areas in stems and leaves. His results conflicted, however, with those of other investigators (*2*), who also had worked with strains of tobacco mosaic virus. The view based on these papers (*2*) was that mosaic viruses do not pass steam-killed sections of stems (unless they are deliberately introduced into tracheary elements) because normally these viruses are unable to pass either into or out of tracheary elements (*3*). Apparently no evidence contrary to this latter view has since been reported either for mosaic viruses or for phloem-limited viruses (*4*), but such evidence has been reported for a xylem-limited virus (*5*).

Our study of the movement of southern bean mosaic virus (SBMV) indicates that this virus, or some part of it capable of initiating infection, can pass into, through, and out of steamed portions of Pinto bean (*Phaseolus vulgaris* L.) stems. In these steamed portions, cells that possess dehydrogenase activity or the capacity of cell division, two activities associated with living cells, could not be detected. Because evidence for this pathway of movement of presumably large particles may interest biologists in various fields, the results obtained are summarized here.

The experimental method followed is based on the fact that when SBMV is introduced into a systemic host (Black Valentine bean) previously grafted to a local-lesion host (Pinto bean) a systemic necrotic reaction associated with multiplication of the virus occurs in the latter bean (*6*). This procedure minimized the possibility of spread of virus above a steamed region unless the primary infections arose from particles that passed through the steamed area, because a systemic spread of virus does not occur with superficial inoculation of Pinto in any region (*6, 7*).

In our experimental procedure each Black Valentine bean plant, which had been previously approach-grafted between the primary leaf node and the soil line region to the same region of Pinto, was mechanically inoculated on trifoliate foliage with SBMV (Fig. 1). A cellophane barrier (not shown in Fig. 1) prevented contact between Black Valentine and Pinto plants. Inoculation was made 24 to 48 hours after a portion of the internode (an inch or more in length) above the primary leaves of Pinto was steamed. Plants thus treated are hereafter designated "grafted-steamed." Each control consisted of an inoculated Black Valentine plant tied, instead of grafted, to an adjacent Pinto. (This combination is hereafter designated "nongrafted control"). In some experiments an additional type of control, Black Valentine grafted to a Pinto (designated "grafted control"), was included. This control indicated whether virus was accidentally introduced into Black Valentine and passed the section of a stem to be steamed after a graft union was established, but before the application of steam. The Black Valentine plant of the grafted control was severed above the graft union and removed about 3 hours after inoculation. An added precaution used to eliminate the possibility of insect introduction of the virus was weekly fumigation and spraying.

Assays, made by a local lesion method (*8*), of two or three samples from tissue four and more nodes above the primary leaf node from each Pinto were used to detect the presence of SBMV (Table 1). The number of lesions resulting from the assay of samples from grafted-steamed plants (38 positive cases) ranged from 0 to 450 per leaf with a mean of 60. The number of lesions resulting from the assay of samples from control plants (4 positive cases) ranged from 0 to 4 with a mean of 0.8. The purpose of the large number of controls (three times the number of grafted-steamed plants) used in the first two experiments was to increase the probability of detection of virus that might have occurred above steamed sections in Pinto without particles having moved through the graft union.

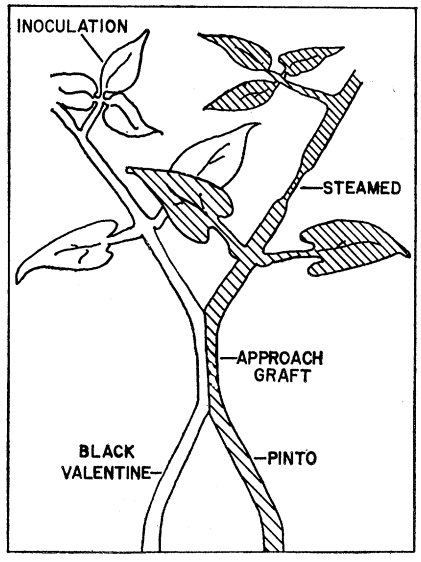


Fig. 1. The relation between the region of inoculation of southern bean mosaic virus and the steamed section in grafted bean plants.

Table 1. Detection of southern bean mosaic virus in Pinto bean plants. The numerator represents total number of Pinto plants in which virus was detected; the denominator represents the total number of plants assayed.

| Expt. No. | Grafted-steamed | Non-grafted control | Grafted control |
|---|---|---|---|
| 1 | 12/12 | 0/36 | |
| 2 | 6/12 | 1/36 | |
| 3 | 9/11 | 0/8 | 0/9 |
| 4 | 11/14 | 1/10 | 2/13 |

In addition to the detection of virus by assay of random samples, necrotic areas were noted above steamed sections in Pinto; these areas contained virus. Such necrotic areas occurred in 18 of the 38 plants in which virus was detected above the steamed portions of stems. The necrotic areas indicate that particles, after passing through steamed sections of stems, reached a cellular environment that supported multiplication. Necrotic symptoms never occurred in the control plants (112 plants).

The source of contamination (Table 1) that would explain the detection of virus in 4 out of 112 control plants is not known. The low virus level and low frequency of this contamination, however, do not account for the frequent high level of virus and the characteristic systemic necrotic symptoms that resulted only on the Pintos of grafted-steamed plants above steamed portions of stems. These symptoms occurred 12 to 36 inches above steamed portions in most cases. As a previous statement in this paper indicates, such a spread of SBMV would not occur from an accidental contamination since this is equivalent to a superficial inoculation of Pinto (*6, 7*).

The steamed sections were studied in