ually they disappeared. Probably death of such bees is a major factor in the diminution of nest populations noted during October, November, and December (Fig. 1, bottom). The records are few and inconclusive, but we think that as pollen collectors die, they are replaced by other, previously relatively inactive bees. Reduction in egg production during November and December (Fig. 1, bottom) as well as other data suggest that egg layers probably also die during

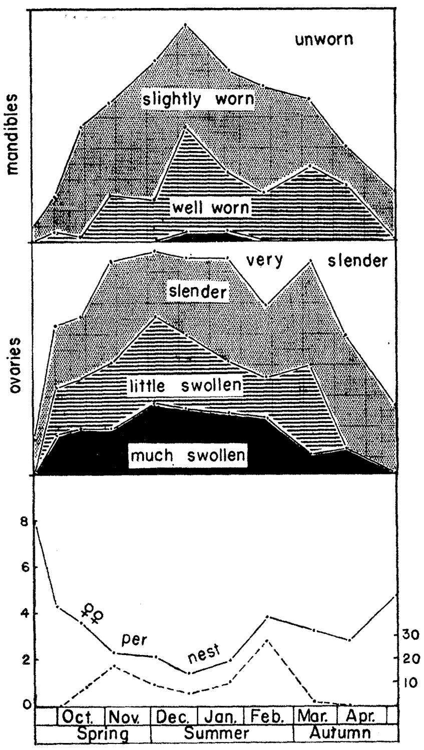

Fig. 1. Nest statistics and conditions of female occupants. (Top) The white and shaded zones vary in width according to the percentage of individuals having mandibles classified as unworn, slightly worn, well worn, and much worn. The four zones total 100 percent in vertical distance at any date. (Middle) White and shaded zones show fluctuations in percentages of females in four groups, classified according to size of ovaries. (For both these sets of percentages, the number of individuals examined was more than 20 for each date, with the exception of early October, when the number in the "middle" group was 11, and of April, when the numbers in the "top" and "middle" groups were 13 and 12, respectively.) (Bottom) Solid line shows average numbers of females per nest, plotted on the scale shown at the left (the number of nests examined, for each date, was 4 to 11, and trends were supported by data from many other nests for which we have only incomplete counts); broken line shows percentage of cells containing eggs, plotted on the scale shown at the right (the number of cells examined, for each date, was more than 49, except for April, when the number was 25).

this period and are only partly replaced from among the previously inactive bees. After the second brood begins to appear, in January, nest populations and egg production rise.

Probably all females leave the nest from time to time to feed. Bees that become pollen collectors may do so more often, while those that become egg layers perhaps do so less often. As bees develop in one or the other of these directions, they show the results of wear, but a number of unworn bees with slender ovaries always remain in the nests. This number decreases steadily (Fig. 1, middle) until January, when new adults emerge. This indicates that bees leave this inactive state to become active either as foragers or as egg layers.

The division of labor described above occurs among bees which do not differ significantly in size, and all of which ordinarily are mated. Clearly, there is no morphological caste differentiation and, as might be expected, male progeny are little if any less numerous than female.

There are, however, a few unfertilized bees in the nests, as determined by examinations of spermathecae for spermatozoa (*6*). Among the overwintering bees dissected in spring and early summer, only one out of 86 was unmated. During January and February, between 15 and 20 percent of the females dissected were unmated; in some cases this was merely because they were young, but others showed wear and presumably would not mate. Over half of the pollen collectors studied during those months were unmated, and we think that most or all of the bees that remain unmated become pollen collectors. Like most other pollen collectors, they have slender ovaries, and usually worn wings and mandibles. Only rarely was more than one such bee found in a nest, and often there was none. Some unfertilized bees were found to be much more worn (with respect both to mandibles and wings) than any fertilized bees of the same age.

It is easy to see that the presence of such active, unfertilized bees might be an advantage to a colony, even though they are nonreproductive. We conjecture that the habit of extensive work on the part of unmated females served as a preadaptation that permitted selection for the regular occurrence of such individuals (workers) and thus provided for the establishment of a worker caste.

In summary, *Augochloropsis sparsilis* exhibits a type of social behavior in which several morphologically similar females, most or all of which mate, occupy a single nest. Division of labor is established, for some females become egg layers, others pollen collectors; cooperative activity includes joint provisioning of cells by two or three bees. A few of the females never mate; these work more than most mated bees, a fact which perhaps provides the basis on which selection can work toward establishment of a regular nonreproducive worker caste.

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References and Notes

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2. C. D. Michener *et al.*, *Ecology*, in press.
3. C. D. Michener, *Proc. Intern. Congr. Entomol. 10th Congr.*, in press.
4. See, for example, W. M. Wheeler, *Social Life among the Insects* (Harcourt, Brace, New York, 1923).
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30 December 1957

Absorption of Cosmic Radio Noise during the Great Aurora of 11 February 1958

During the night of 10–11 February 1958 observers in clear portions of the United States witnessed one of the largest aurorae of the current sunspot cycle. Although heavy clouds blanketed Boulder, Colorado, two receivers normally used for measurements of the absorption of 18 Mcy/sec galactic radio noise operated throughout the night. One of these receivers recorded the total power from a vertically-beamed antenna approximately 50 by 90 deg wide between the half-power points. The other receiver measured power in a two-element, Ryle phase-switching interferometer with a baseline 16.8 wavelengths long, oriented at an azimuth 41 deg east of north. The elements of the interferometer were steerable corner reflectors with beams 40 deg wide and 60 deg high, at a fixed orientation elevated 35 deg toward the northeast. The output of the interferometer split into two channels, one recording the average power (called "total power") between the two halves of the Ryle switch axle, the other the power difference (called "phase power") between the two half-cycles.

Figure 1 shows the three records. Two principal events occurred, between 0545

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

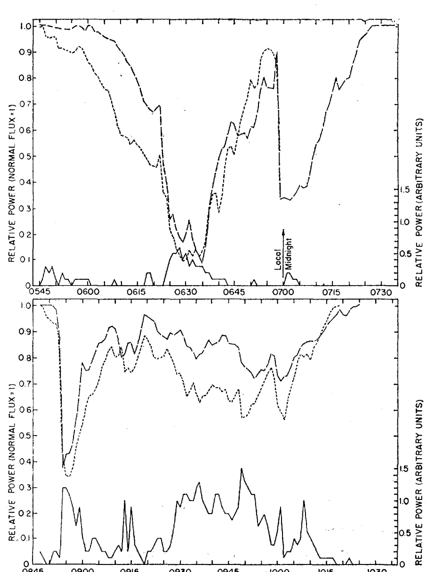

Fig. 1. Dashed line, total power in the interferometer system; broken line, power in the vertical beam (read values on the left-hand scale, normalized so that the unit is power level outside of the aurora); solid line, phase power (of constant sign) in the Ryle interferometer (read values from the right-hand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

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.

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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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