Solar geomagnetic disturbances and weather

by John Gribbin

ONE of the key links in the developing theory that atmospheric circulation (and hence climate) on Earth is affected by solar activity has been provided by evidence that geomagnetic activity can be connected with a deepening of troughs in the atmosphere. But although evidence presented by Roberts and colleagues (see *J. atmos. Sci.*, **30**, 135–140; 1973) has seemed to show that troughs at the 300 mbar level level are affected in this way, and although other groups have presented evidence that even surface pressure responds to solar geomagnetic disturbances (see Mustel, *Soviet astr.*, **10**, 288–294; 1966) the reality of the claimed effect has been queried by others. In particular, Stolov and Shapiro found no evidence to support the claim that atmospheric circulation is disrupted during disturbed geomagnetic periods, according to a paper published three years ago (*Proc. Symposium on Solar Corpuscular Effects in the Troposphere and Stratosphere*, Moscow, 1971). So the recent publication of another paper by the same two authors, in which they report that a reanalysis of the data does show such an effect, is particularly important (*J. geophys. Res.*, **79**, 2161–2170; 1974).

The reason for the emergence of the effect from the new analysis seems to be that the strong seasonal trend in 700 mbar heights which is introduced by ordinary meteorological factors must be removed before the solar geomagnetic effect can be picked out from the data. The data themselves are comprehensive, covering the period January 1, 1947 to December 31, 1970. They consist of sea level pressures and 700 mbar heights measured at 5° latitude intervals and 10° longitude intervals in a diamond shaped grid over 20° to 70° N. The solar geomagnetic incidents studied in the analysis were chosen from a variety of sources which gave a total of 454 events, some of which were related to one another.

Using a superposed epoch analysis and removing the seasonal effects which dominate the atmospheric variations, Stolov and Shapiro find "firm statistical evidence . . . that strongly suggests the existence of a real relationship between solar geomagnetic storms and the subsequent behaviour of the 700 mbar contour height". The effect is more pronounced in winter, when the zonal flow is increased 4 days following geomagnetic disturbance. In summer, a smaller but still significant effect occurs 2 days after such disturbances. At its maximum (for the quadrant 90° to 175° W in winter) the effect corresponds to a 7% increase in the mean westerly flow. Stolov and Shapiro say that "no acceptable physical observations are available to explain the observations"; however, that no longer seems to be strictly true in the light of King's recent investigation of links between the magnetosphere and atmosphere (*Nature*, **247**, 131–134; 1974). What is certainly true is that further statistical studies are needed, and that these might contribute both to weather forecasting and to an understanding of climatic change.

Vole populations and their diet

from our Animal Ecology Correspondent

ONE of the greatest drawbacks to the theories which purport to explain the factors causing vole population cycles is their relative untestability (for example, Chitty, *Can. J. Zool.*, **38**, 99; 1960; Christian and Davis, *J. Mammal.*, **47**, 1; 1966) and recent attempts to elucidate behavioural or genetic factors have been inconclusive. Batzli and Pitelka (*Ecology*, **51**, 1027; 1970) and Schultz (*Symp. Brit. Ecol. Soc.*, 57; 1964) have suggested that nutritional aspects of forage may play an important part in regulating cycles. These could take the form of potassium or phosphorous deficiencies which bring about specific or general debility.

Another nutritional factor which might be involved is the toxicity of many food species of plant (Freeland, *Am. Nat.*, **108**, 238; 1974). From the huge mass of published work on species preferences of vole food at various stages of the population cycle, Freeland argues that the loss of animals from peak population densities is the direct result of reduced viability induced by the consumption of plants, or parts of plants, that contain toxins. It is known that quite small amounts of toxins imbibed by voles cause inhibition of protein synthesis and growth, cessation of the reproductive processes, occurrence of megalocytes in the liver together with haemorrhagic necrosis, hypertrophy of the spleen, and cause neural and digestive disorders. If a vole eats more than one toxic species the effect of the toxins they contain may be mutually enhanced.

Freeland puts forward a hypothesis with four central tenets: (1) voles must have a preference for non-toxic species; (2) with increasing population numbers these preferred foods should become scarcer with a concurrent increase in availability of non-preferred, toxic species; (3) at high population densities voles ingest quite large quantities of toxic foods leading to a reduction in growth and a slowing of reproduction; and (4) in the absence of grazing, the preferred non-toxic species should compete more strongly for space than the less preferred toxic species. The replenishment of favoured food so produced following a 'crash' of population allows another cycle to start.

In 1965 Thompson (*Amer. Midl. Natur.*, **74**, 75) examined the toxicity level of many food species of the voles *Microtus pennsylvanicus* and *M. californicus* in relation to their preferences of selection. A plant was ranked as toxic only if it was known to contain a compound or compounds that cause death or severe physiological damage. Bitter tasting or foul smelling species were not rated as toxic unless a truly toxic compound occurred as well. The result of Thompson's laboratory trials was that voles prefer non-toxic plants like *Trifolium repens* and *Lolium multiflora* to toxic ones like *Ranunculus* and *Rumex*. Batzli and Pitelka have found that during one cycle of *Microtus* abundance the amount of toxic species available becomes relatively more abundant in the face of a diminishing supply of preferred species. The establishment of exclosures indicated that non-toxic species out-compete toxic ones. In areas grazed by voles there is a reciprocal fluctuation of the relative abundances of these two species types.

Krebs *et al.* (*Ecology*, **50**, 587; 1969) have noted that during population decline the rates of disappearance of different age and sex classes of voles are not the same. There is evidence that male sex hormone increases the activity of liver microsomal enzymes which bring about the degradation of toxins (Parke, *The Biochemistry of Foreign Compounds*, Pergamon, Oxford; 1968). So the differential mortality rates frequently observed by field workers is a phenomenon not incompatible with Freeland's hypothesis.

The crux of the hypothesis is that numerical change must come about sufficiently slowly for there to be a compositional change in the vegetation. Even though *Microtus* and similar rodent species have a high capacity for population increase, natural wastage to predation keeps the numbers low enough to avoid a hasty overgrazing of the vegetation. The slow build-up of rodent numbers produces a slow increase in availability of toxic species which, in time, decreases rodent abundance and allows the whole cycle to start again.

This hypothesis has merit and warrants close scrutiny. At the same time could population ecologists consider not so much how the cycle works as much as why it happens at all? Are cyclical rodents really in such a bad state of balance with their ecosystems, or is there another reason?