

effect similar to that of certain poisons, such as morphia, or cocaine, when introduced in the usual way from outside.

'And so you get the hectic flush', said Hans Castorp. 'But that's all worth hearing. What the man doesn't know! He must have simply lapped it up. You just wait, one of these days he will discover what that substance is that exists everywhere in the body and sets free the soluble toxins that act like a narcotic on the nervous system; then he will be able to fuddle us all more than ever. Perhaps in the past they were able to do that very thing. When I listen to him, I could almost think there is some truth in the old legends about love potions and the like . . .'

## Palaeoecology

# Distributions of desert plants

from Peter D. Moore

STUDYING the history of vegetation and climate in arid parts of the world presents far more problems than it does in damper climes. The availability of lake sediments and peat deposits in most temperate and many tropical areas has led to extensive studies of biological, geological and chemical materials that have permitted some detailed reconstructions of past environments. But although fossil lakes have been studied in some deserts, for example, the Rajasthan<sup>1</sup> and the Sahara<sup>2</sup>, their scarcity has forced palaeoecologists to seek other sources of evidence concerning the former distribution of vegetation in these dry areas. Such sources include mammalian rubbish heaps<sup>3</sup>, or middens, and, more recently, the analysis of carbon isotope ratios either in plant and animal macrofossils or in the organic varnishes coating the desert rocks<sup>4</sup>.

The habit of animals such as packrats (*Neotoma* spp.) and porcupines (*Erethizon dorsatum*) to create piles of organic detritus, and the fact that these materials survive in arid climates for many thousands of years, has provided a useful opportunity for analysing past plant-distribution patterns and migration routes. Allowance must be made, however, for such factors as the dietary preferences and the foraging range of the animals concerned. In New Mexico, the course of migration of trees since the last glaciation has been followed by the analysis of the macrofossils in 13 middens found in the northern Chihuahuan Desert<sup>5</sup>. It is found that the pine (*Pinus edulis*) and juniper (*Juniperus scopulorum*) vegetation of the full glacial (18,000 year BP), which reflects less extreme climatic conditions, is gradually replaced by woodlands in the early Holocene, indicating mild wet winters together with warmer summers<sup>6</sup>. This vegetation gives way to desert grassland in the mid-Holocene and finally to present-day desert scrub. The invasion of such plants

There is little to add except that we expect many new developments in the opioid field. □

1. Oka, K., Kantrowitz, J. D. & Spector, S. *Proc. natn. Acad. Sci. U.S.A.* **82**, 1852 (1985).
2. Goldstein, A. *et al. Proc. natn. Acad. Sci. U.S.A.* **82**, 5203 (1985).
3. Kosterlitz, H.W. *Proc. R. Soc. Lond.* **B225**, 27 (1985).
4. Sonders, M., Barchas, J. D. & Weber, E. *Biochem. biophys. Res. Commun.* **122**, 892 (1984).
5. Gieud, P., Castanas, E., Patey, G., Oliver, C. & Rossier, J. *J. Neurochem.* **41**, 154 (1983).
6. Brochmann-Hanssen, E. in *The Chemistry and Biology of Isoquinoline Alkaloids* (eds Phillipson, J. D., Roberts, M. F. & Zenk, M. H.) 229 (Springer, Berlin, 1985).
7. Mann, T. *The Magic Mountain* 3rd edition, 188 (Secker & Warburg, London, 1961).

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as the creosote bush (*Larrea divaricata*) first occurred in the Sacramento Mountains just before 3,000 yr BP.

Altitudinal changes in vegetation during the Holocene have also been studied using packrat middens in the Californian Mojave Desert<sup>5</sup>. By studying a single hill, changes in the altitudinal boundary between creosote bush and blackbrush (*Coleogyne ramosissima*) scrub communities can be traced. Analyses of fossil middens show the arrival and expansion of *Coleogyne* at the expense of *Larrea* during the past 500 years, indicating the development of cooler, damper conditions. A degree of sophistication was added to this analysis by running control analyses of the contents of modern middens under known vegetation conditions and by applying ordination techniques to show trends in vegetation development.

Another fashionable palaeoenvironmental technique is the use of the ratio of carbon 13 to carbon 12 in fossil organic material from arid lands. The ratio of these isotopes in organic compounds derived from photosynthetic activity depends primarily on the photosynthetic mechanism used by the plant. Plants using a C<sub>3</sub> strategy of carbon fixation generally have isotope ratios in the region of -27 parts per thousand (p.p.t.) (relative to a standard material), whereas those using a C<sub>4</sub> or a crassulacean acid metabolism (CAM) strategy produce organic compounds with a ratio of around -13 p.p.t. This fact has been of some value in studies of the evolutionary history of the C<sub>4</sub> strategy of photosynthesis<sup>6,7</sup>; it also aids in tracing changes of diet, like the switch to maize (a C<sub>4</sub> plant) by the American palaeo-Indians, as the isotope ratio is found in the bone collagen of herbivorous animals<sup>8</sup>.

The use of isotope ratios for the detection of fossil photosynthetic strategies is made more complex by the innate variability of the ratio and also by the influence of

climate. The variation induced in the carbon compounds of tree rings is less than 2 p.p.t.; this fluctuation provides another technique for climate reconstruction<sup>9,10</sup>.

In arid lands, carbon ratio measurements have been conducted on plant material from fossil samples in caves and packrat middens in Nevada<sup>11</sup>. In the CAM plant *Opuntia polyacantha*, for example, samples with an age of over 40,000 years had a ratio of -21.9 (indicative of C<sub>3</sub>-type metabolism), whereas samples from 10,000 years ago gave a carbon ratio of -13.9 p.p.t. (showing the operation of the CAM system). This is taken to demonstrate the more arid conditions at the beginning of the Holocene<sup>11</sup>.

This approach is limited by the availability of macroscopic fossil plant material, which is often scarce in deserts. An alternative source of organic carbon, obtained from several sites in North America and in the deserts of the Sinai Peninsula, has recently been tested<sup>4</sup>. The material used is the varnish that coats rock surfaces, derived from minute airborne particles of plant organic matter. This matter, used as an energy resource by micro-organisms, accumulates slowly. Dorn and DeNiro propose that the varnish has a carbon isotope ratio that reflects the balance of photosynthetic strategies in the surrounding plant community<sup>4</sup>, and that organic metabolites produced by microbes will continue to maintain the original ratio in a similar way to that of the bone collagen of herbivores. They put these ideas to the test by analysing modern rock varnish from a range of sites with known vegetation and climate and find that most arid sites have values between -11 and -16 p.p.t., while semi-arid and humid sites often have values below -22 p.p.t. These figures indeed reflect the balance of C<sub>3</sub>, C<sub>4</sub> and CAM plants in the areas of study. Some preliminary tests on stratified material also indicate that the method is appropriate for the study of vegetational and environmental changes over many thousands of years. More detailed work is now needed on modern processes of varnish accretion and its relationship to local vegetation, but it seems that palaeoenvironmentalists now have a powerful new tool to apply to the study of desert history. □

1. Singh, G., Joshi, R.D., Chopra, S.K. & Singh, A.B. *Phil. Trans. R. Soc.* **B267**, 467 (1974).
2. Richie, J.C., Eyles, C.H. & Haynes, C.V. *Nature* **314**, 352 (1985).
3. Van Devender, T.R., Betancourt, J.L. & Wimberly, M. *Quatern. Res.* **22**, 344 (1984).
4. Dorn, R.I. & De Niro, M.J. *Science* **227**, 1474 (1985).
5. Cole, K.L. & Webb, R.H. *Quatern. Res.* **23**, 227 (1985).
6. Troughton, J.H. in *Photosynthesis and Photorespiration* (eds Hatch, M.D., Osmond, C.B. & Slatyer, R.O.) 124 (Wiley, New York, 1971).
7. Smith, B.N. & Robbins, M.J. *Proc. 3rd. Int. Congr. Photosyn.* 1579 (Rehovot, 1974).
8. Van der Merwe, N.J. *Am. Sci.* **70**, 596 (1982).
9. Pearman, G.L., Francey, R.J. & Fraser, P.J.B. *Nature* **260**, 771 (1976).
10. Leavitt, S.W. & Long, A. *Nature* **311**, 145 (1984).

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