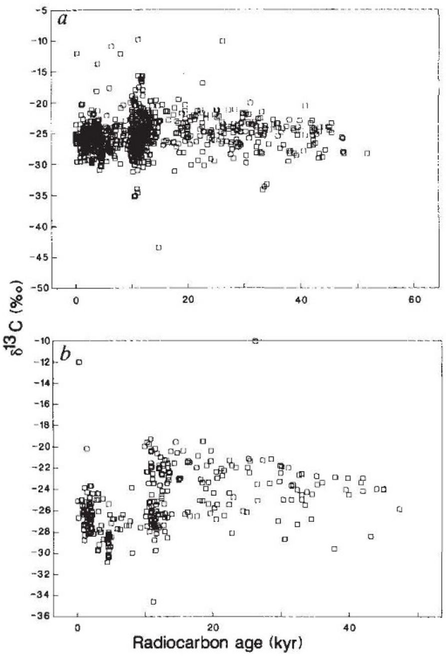
Chronology from plant matter

SIR — In the absence of direct, long-term measurements of carbon isotope ($^{13}C/^{12}C$) ratios of CO_2 in ice cores, Krishnamurthy and Epstein have derived[1] a possible atmospheric $^{13}C/^{12}C$ chronology using isotope measurements from 115 old wood samples. They found a $\delta^{13}C$ peak at about 20 kyr before present (BP) with a decline of about 4‰ toward present and about 3‰ back to 40 kyr BP. We have tabulated more than 800 $\delta^{13}C$ values on ^{14}C-dated plant matter published in *Radiocarbon* (University of Arizona, Tucson) between 1959 and 1989. The material includes wood, charcoal, peat, leaves, twigs, pine cones and seeds.

The figure depicts the results for all data and for wood. We judged the most visible dislocation in $\delta^{13}C$ to occur at about 10 kyr BP and calculated means before and after that time. For all data, the pre-10 kyr BP mean is 0.8‰ heavier (more positive) than post-10 kyr BP (n=821, P<0.01), and for the wood the pre-10 kyr BP mean is 3.0‰ heavier than post-10 kyr BP (n=306, P<0.001). Specific subcategories of *Pinus* and gymnosperms also show a similar significant decline as that found for all wood.

The magnitudes of the wood $\delta^{13}C$ decline toward the present is comparable to that found in ref. 1, but there is no $\delta^{13}C$ peak at 20 kyr BP in the data we have analysed. Whereas Krishnamurthy and Epstein attribute the change they found to large $\delta^{13}C$ changes of atmospheric CO_2, an increase in the average ratio of plant intercellular CO_2 to external (atmospheric) CO_2 partial pressure (p_i/p_a) from 0.78 in the glacial to 0.87 in the post-glacial alone could explain the $\delta^{13}C$ change presented here, according to plant carbon-isotope fractionation models[2]. Isotopically heavier $\delta^{13}C$ values found in high elevation plants throughout the world[3] may be evidence of lower atmospheric CO_2 partial pressure favouring reduced p_i/p_a.

Many questions remain, such as why neither our peat (n=146) nor our charcoal (n=256) samples show any significant changes. Furthermore, analysis of material from many locations by different laboratories, in addition to inherent physiological complexities, may confound attempts at accurate reconstruction. Long reconstruction with wood or with C4 plants[4] from a single location may offer the best hope for atmospheric reconstructions from plant matter.



a, The $\delta^{13}C$ values of all tabulated plant matter; pre-10 Kyr BP mean, −25.0‰, s.d., 3.2‰; post-10 Kyr BP mean, −25.8‰, s.d., 2.8‰. *b*, $\delta^{13}C$ Values of all tabulated wood values; pre-10 Kyr BP mean, −24.1‰, s.d., 2.7‰; post-10 Kyr BP mean, −27.1‰, s.d., 2.4‰. The outliers (−12 and −10‰) are either woody C4 plants or printing errors. Although included in the calculation of the means, their influence is minimal.

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1. Krishnamurthy, R. V. & Epstein, S. *Tellus* **42B**, 423–434 (1990).
2. Farquhar, G. D. *et al. Aust. J. Plant Physiol.* **9**, 121–137 (1982).
3. Körner, C. *et al. Oecologia* **74**, 623–632 (1988).
4. Marino, B. D. & McElroy, M B. *Nature* **349**, 127–131 (1991).

Sperm competition

SIR — Since Parker[1] first pointed out the importance of competition between sperm from different males for fertilization of eggs of a single female, many studies have shown the importance of mating order in determining paternity patterns. Yet the underlying mechanism is known in only a few cases[2]. In the acarid mite (*Caloglyphus berlesei*), the sperm from the last male to mate with the female has precedence over previously deposited sperm[3]. We have now shown that this occurs because the last male to mate repositions the sperm from previous matings, thus achieving most of the fertilizations.

The design of our experiments was based on data suggesting that no sperm are transferred in the first few minutes of copulation, but that some process which decreases fecundity of previously mated females takes place (J.R., unpublished observations). Females were allowed to mate with virgin males under three different regimes. In the control group, each female mated with one male and finished copulation naturally. In experimental group 1, naturally terminated copulation was immediately followed by matings with four other males, and each of these copulations was experimentally interrupted after 5 min. The order was reversed in group 2: four matings interrupted after 5 min were followed by a naturally terminated copulation. After matings, some females were collected to be prepared for both light and electron microscopy.

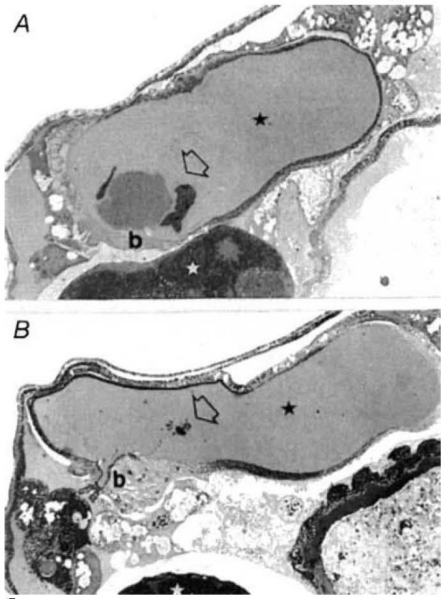
Females from group 1 deposited many fewer eggs than the control females (see table). After serial sectioning of the control females' spermathecae, a mass of several hundred sperm cells was consistently found in the basal part of the spermatheca, where efferent ducts leading to ovaries are located (*A* in the figure). When a naturally terminated mating was followed by four 5-min copulations, however, no sperm were found within the basal part: the sperm cells were scattered in the fluid filling the

NUMBER OF EGGS DEPOSITED BY FEMALES

	Eggs per female (± S.D.)	P
Control (n=14)	119.4 (± 49.3)	
Group 1 (n=8)	25.4 (± 25.0)	0.001
Group 2 (n=7)	106.6 (± 65.4)	0.837

Eggs were counted daily for 10 consecutive days. Females did not oviposit for longer than 6 days.

See ref. 5 for details of methods. P-values are given for the differences between the two experimental groups and the control (Tukey–Kramer test).



Axially sectioned spermathecae composed of basal part (**b**) and sac (black asterisk), showing distribution of semen (arrow). *A*, Control (three females processed); *B*, group 1 (four females). White asterisk, ovary. Magnification x 275.