Accuracy of Buffon's 200-year-old experimental data

SIR—I have analysed the experimental data of Buffon[1,2] concerning the properties of wood (breaking load, drying and dampening) and the cooling time of iron spheres extracted from a furnace and allowed to cool in air. The quality of the graphs that can be drawn from these data indicates Buffon's rigour in applying experimental method.

Georges Louis Leclerc, count of Buffon (1707–1788) conducted numerous experiments on wood [3-5], especially oak, particularly important at that time for the construction of ships, houses, bridges, mills and so on. Buffon wanted to verify Galileo's law on the breaking load of a plank, $P = k\,a\,b^2/L$ where P is the breaking load, a is the width, b is the thickness, L is the length and k is a constant of proportionality. He found that Galileo's law is of limited value applying better to solid, inflexible materials which reach their breaking load without previously bending. Moreover the law has greater validity when the planks are shorter. Figure 1 shows that Buffon's data for oak planks which bend before breaking, with the exception of high L values at which strong deviations from linearity occur, are consistent with the equation of the type $P = k\,a\,b^2/L^{5/4}$.

Some of Buffon's experiments on the drying of wood and its retention of humidity took more than 20 years to perform. Figure 2 shows a semilogarithmic plot of the weight of an oak parallelepiped, exposed to air but protected from the rain, as a function of time. It is possible to see some fluctuations resulting from the partial retention of humidity in winter. If Buffon had been able to compose graphs of this type he could have deduced that water is lost from the surface and through three types of aperture in wood. Water absorbed by the surface is lost in 4–5 days (behaviour I, Fig. 2*a*). Water is lost from holes between the fibres in one month (behaviour II, Fig. 2*a*). Water from long, thin tubes running longitudinally along the trunk of the tree is lost in about eight months (behaviour III, Fig. 2*b*). Finally, water loss through single cells needs eight years to reach an equilibrium (behaviour IV, Fig. 2*b*).

In 1749, Buffon began experiments to determine the age of Earth[3,4], measuring

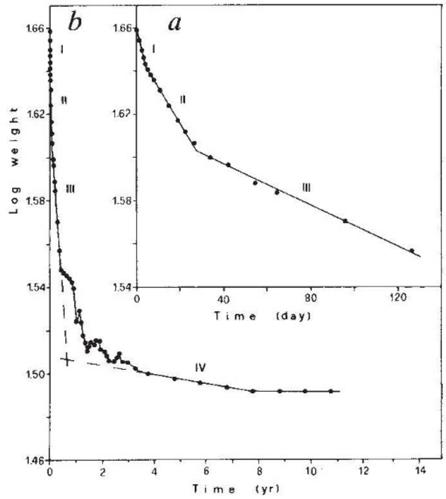

Fig. 2 Drying of an oak parallelepiped (14.2 × 8.2 × 9.4 inches).

cooling times of iron balls of various diameters, from red heat to temperatures of about 60 and 15 °C, respectively (Fig. 3). Buffon calculated that the Earth's age would be 100,696 years if it was composed solely of iron. In fact, he believed the

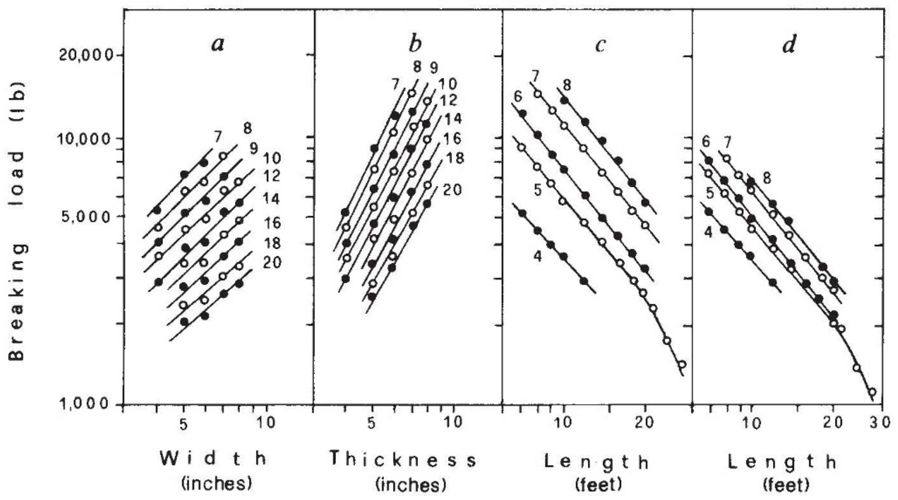

Fig. 1 Buffon's experimental data obtained from oak planks with square cross section are treated to separate the effects of the parameters *a*, *b*, *L* to clarify the dependence of breaking load: *a* on width at various lengths and the same thickness (4 inches); *b* on thickness at various lengths and the same width (4 inches); *c* on length at various thickness and the same width (4 inches); *d* on length at various widths and the same thickness (4 inches). The numbers near the straight lines indicate: in *a* and *b* the length of the planks; in *c* the thickness; in *d* the width.

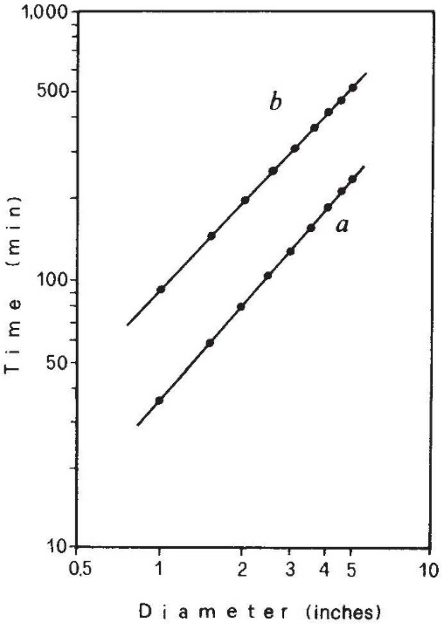

Fig. 3 Logarithm of the cooling time of iron balls with respect to the logarithm of their diameter. *a*, Cooling from red heat to about 60 °C; *b*, cooling from red heat to about 15 °C.

Earth is a mixture of glass, quartz, marble and ferrous minerals, and therefore that it should cool more quickly than iron. He then calculated the Earth's age to be 74,047 years. This is about 13 times greater than 5,750 years, the age based on calculations made in the seventeenth century by archbishop Ussher and generally accepted in Buffon's day. By assuming an average diameter of 12,470 km for the Earth, and from the slope of the straight line *b* of Fig. 3, a cooling time of 100,000 years can be calculated. This agrees completely with Buffon's calculations from the premise of an iron-based Earth.

The work I have described here confirms by the beauty of the graphs which can be drawn from Buffon's data, the rigour of this scientist in applying experimental method.

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2. Piveteau, J. *Oeuvres philosophiques de Buffon* (Presses Universitaires de France, Paris, 1954).
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4. Barr (trans) *Buffon's Natural History General and Particular* (London, 1792–93).

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