MATTERS ARISING

The arrival of *Equus*

EVEN though papers which attempt to draw together a lot of diverse evidence are most important for the scientific community the authors of such papers should not neglect to acknowledge the basic analytical work on which they base their discussion. I feel that J. Brunet and I deserve to be quoted in discussion of the arrival of *Equus* in the Old World at least for Roccaneyra[2], probably the earliest European site to have yielded *Equus*, and probably the only one where *Equus* and *Hipparion* coexist. So far as I know, it was not V. J. Maglio[3] but D. A. Hooijer[4] and myself[5] who, independently, stated that the first occurrence of *Equus* in the Omo beds was in member G of the Shungura Formation. Since 1973, we have often repeated that the arrival of *Equus* in Africa was about two million years ago[4–9].

Lindsay *et al.*'s[1] bibliography is quite instructive. Most of the papers cited on the first occurrence of *Equus* in Europe and Africa are themselves reviews, rather than original papers describing new material or stating new facts. People like J. Brunet, who has worked for years with equids, or D. A. Hooijer and myself, who have published about 30 papers dealing with equids, are ignored, although we were responsible for the basic descriptions and determinations.

I am sure that any specialist whose colourless original work has been neglected, involuntarily or not, in more appealing papers will understand why I decided, even so late, to write about such a trifle.

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1. Lindsay, E. H., Opdyke, N. D. & Johnson, N. M. *Nature* **287,** 135–138 (1980).
2. Eisenmann, V. & Brunet, J. in *Int. Colloquium on the Problem 'The Boundary Between Neogene and Quaternary'* **4,** 104–122 (Moscow, 1973).
3. Maglio, V. J. *Nature* **239,** 379–385 (1972).
4. Hooijer, D. A. in *Earliest Man and Environments in the Lake Rudolf Basin* (eds Coppens, Y., Howell, C. F., Isaac, G. Ll. & Leakey, R. E. F.) 209–213 (University of Chicago Press, 1976).
5. Eisenmann, V. in *Earliest Man and Environments in the Lake Rudolf Basin* (eds Coppens, Y., Howell, C. F., Isaac, G. Ll. & Leakey, R. E. F.) 225–233 (University of Chicago Press, 1976).
6. Hooijer, D. A. *Zool. Verh., Leiden* **142,** 1–75 (1975).
7. Hooijer, D. A. *Zool. Verh., Leiden* **148,** 1–39 (1976).
8. Eisenmann, V. *Bull. Mus. natn Hist., nat., Paris* **438,** 69–87 (1977).
9. Eisenmann, V. *Bull. Soc. geol. Fr.* **21,** 277–281 (1979).

LINDSAY *ET AL.* REPLY—We regret that the important palaeontological contributions of Dr Eisenmann and others were slighted in our references. This was unintentional, but resulted from a bias towards selection of references with a chronological rather than a palaeontological message.

Certainly, the paper by Eisenmann and Brunet[1] on the co-occurrence of *Equus* and *Hipparion* at Roccaneyra is an important palaeontological contribution for recognition of the appearance of *Equus* in Europe. Our study was initiated with the expectation that the record of *Equus* at Montopoli would be demonstrably earlier than that at Roccaneyra, and we were more impressed with the proximity of their age assignment than with the palaeontological identity of the equids at Roccaneyra and Montopoli.

We cited Maglio[2] as an early review of East African biochronology in which faunal levels were characterized, including the *Mesochoerus limnetus* zone, with the appearance of *Equus*. Correlation of this faunal sequence had been questioned because of similar faunas with conflicting radiometric limits in the Shungura and Koobi Fora Formations—that conflict was resolved after further work on the radiometric dating, as discussed by Drake[3]. Our emphasis was on resolution of the conflict, and we concluded that the appearance of *Equus* in deposits of the Omo Basin, east of Lake Turkana, was contemporaneous with that at Olduvai Gorge. Unfortunately, we did not acknowledge the palaeontological contributions of Hooijer[4], Eisenmann[5], Churcher[6], and others.

We think there might be a strong tendency for reviewers to cite other reviews, and similarly for analytical contributions to cite other analytical contributions. In spite of this, we recognize and appreciate the numerous palaeontological, radiometric, and stratigraphic studies of many researchers whose work we drew on for our review.

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1. Eisenmann, V. & Brunet, J. in *Int. Colloquium on the Problem 'The Boundary between Neogene and Quaternary'* **4,** 104–122 (Moscow, 1973).
2. Maglio, V. J. *Nature* **239,** 379–385 (1972).
3. Drake, R. E., Curtis, G. H., Cerling, T. E., Cerling, B. W. & Hampel, J. *Nature* **283,** 368–372 (1980).
4. Hooijer, D. A. in *Earliest Man and Environments in the Lake Rudolf Basin* (eds Coppens, Y., Howell, C. F., Isaac, G. Ll. & Leakey, R. E. F.) 209–213 (University of Chicago Press, 1976).
5. Eisenmann, V. in *Earliest Man and Environments in the Lake Rudolf Basin* (eds Coppens, Y., Howell, C. F., Isaac G. Ll. & Leakey, R. E. F.) 225–233 (University of Chicago Press, 1976).
6. Churcher, C. S. *Zool. Meded., Leiden* **55,** 265–280 (1980); *Can. J. Earth Sci.* **18,** 330–341 (1981).

Pulsar birthrates

NARAYAN AND VIVEKANAND[1] have obtained a minimum estimate for the birth rate of pulsars in the Galaxy of 1 pulsar per $(100^{+100}_{-30})f$ yr, where $f(=K^{-1}) \leq 1$ is the beaming factor. They have obtained this estimate from the flow rate in period space, without recourse to the spin-down age $\tau := P/2\dot{P}$. At the same time, their estimated number of pulsars in the Galaxy is $N = 1.4 \times 10^{5\pm0.3}/f$, and they find that τ is a good measure of age for $\tau \lesssim 0.5 \times 10^6$ yr. Their method is elegant, but I find it hard to trust their result quantitatively, for the following reason.

Their birth rate N implies a mean pulsar age $N/\dot{N} \approx 4 \times 10^7$ yr which is some 10 times larger than the average age determined[2] both from the fraction of young pulsars ($\tau < 10^6$ yr, for which τ is held to be a good measure of age) and from the kinematic ages $z/\dot{z}$, and also[3] from the histogram of spin-down ages. It would imply that τ underestimated the true age. However, according to our understanding of pulsars, τ measures their age for a dipole-coupling to their surroundings, and can only lose its property of an age indicator in the presence of some overtaking ageing mechanism (such as spin alignment[4]), in which case it would overestimate the true age.

If the birth rate derived by Narayan and Vivekanand can be trusted vaguely, it means that τ is not always as large an overestimate of age as suggested by kinematic ages. Such a trend does not surprise me in view of the two populations of pulsars which are expected if pulsars are born in binary systems[5]. A large fraction of all τ -old pulsars may be 'elder twins' born with a large τ_0 ($> 10^6$yr, instead of $\lesssim 10^3$ yr), and for which τ is not a significant overestimate of age. At the same time, if pulsars are in general the younger twins, the birth rate of neutron stars should be approximately twice that of pulsars.

Another word of caution concerns the beaming factor whose value is often assumed to be 0.2. This estimate follows from the assumption of an almost circular beam cross-section, and independently from the fact that most supernova remnants lack a central pulsar. However, supernova remnants housing a pulsar would almost certainly have a filled-centre appearance, that is, be plerions, whereas shell-type remnants are expected[5] to contain binary system neutron stars (like W50 around SS433). Moreover, pulsar beams may well have banana-shaped cross-sections, with $f \approx 1$. A beaming factor f near unity is likewise indicated by the high occurrence rate of interpulses ($\approx 5\%$) if the latter come from the opposite magnetic pole.

With these modifications and ref. 2 in

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