

might contribute not only to fire ant control but also to an understanding of parasitism's role in structuring natural communities.

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Leukaemia and wartime evacuees

SIR — A high degree of mixing of urban and rural groups of people is associated with significant increases of childhood leukaemia, a phenomenon that is consistent with an infective process being responsible¹⁻⁷.

The evacuation by the government of large numbers of urban children during the Second World War is such a situation, which we have recently studied in relation to childhood leukaemia⁸.

The 476 rural districts of England and Wales were grouped into three categories with similar numbers of local children but with contrasting proportions of government evacuees in 1941. In the 'high' category, leukaemia mortality in the years 1945-49 (the earliest period for which data are available) showed a 47% excess relative to the 'low' category, with a significant trend across the categories. Doubt has been cast in Scientific Correspondence⁹ on this infection-based hypothesis because mortality rates from childhood leukaemia in England and Wales showed no sudden increase during or just after the war. National mortality rates are inevitably rather insensitive to changes in rural areas, given the small proportion of the country's children who live there (and in fact the 'high' rural category held only 6.3%). Wartime evacuation therefore does not represent an exception in this context.

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Organic carbon in sediments

SIR — Hartgers *et al.*¹ convincingly demonstrate the presence of derivatives of isorenieratene and a novel C₄₀ diaromatic carotenoid in the aromatic hydrocarbon fractions of Duvernay Formation sourced crude oils, and in chemical and pyrolytic degradation products of associated crude oil asphaltene and source rock kerogens. From this they argue that there are contributions from green sulphur bacterial components in the sedimentary organic matter in the Palaeozoic sediments of Western Canada and elsewhere. The authors further suggest that because these biomarker compounds — indicative of a specific group of photosynthetic bacteria — show carbon isotope signatures significantly different from the bulk total organic carbon (TOC), these organisms have not contributed significantly to the carbon preserved in the sediments from Western Canada and the Williston basins.

We agree with this conclusion, as well as with the argument of Hartgers *et al.*¹ that substantial biases occur in the quantitative interpretation of biological marker data in terms of source biomass contribution to bulk TOC. This bias is likely to occur in quantitative assessments of biological marker contributions from bound fractions, particularly when relative concentrations of components in gas chromatograms are used.

Nevertheless, we are cautious about the overall general conclusion of the paper¹. The inference that bacterial biomass (implying all bacteria) is a minor component of sedimentary organic matter has not yet been tested and, indeed, remains one of the most important questions in biogeochemistry. Hartgers *et al.*¹ suggest that selective preservation of specific biomarker compounds has led to overstating their significance as indicators of sources of sedimentary organic matter. Although undoubtedly true in this specific case, and perhaps more widely², this suggestion does obscure the wider, more significant, issue that microorganisms other than photoautotrophs are likely to contribute considerable amounts of organic carbon to sedimentary basins. The arguments for this are twofold: (1) the work of Parkes *et al.*³ shows that there is significant bacterial production resulting from growth of bacteria on organic matter deposited in sediments from the overlying water column; and (2) in present-day marine basins, typically 18–30% of photosynthetically fixed carbon contributes to the growth of heterotrophic bacteria⁴ and in some highly eutrophic environments up to 80% of photosynthetically fixed carbon is converted to bacterial biomass⁵. This may be of consequence in the light of pre-

liminary evidence for the occurrence of resistant macromolecular components in some bacteria⁶.

The contribution of bacterial biomass to the global carbon budget is of fundamental importance to the biogeochemistry of our planet, having consequences not only for the biogeochemical cycling of oxygen and carbon, but also for palaeoenvironmental reconstructions and the formation of oil-prone sediments. In combination, the arguments of Parkes *et al.*³ and of Ducklow and Carlson⁴ indicate that non-photosynthetically produced bacterial biomass must be significant in the formation of sedimentary organic matter in general. At the other end of the spectrum, the TOC in sediments from the extreme environments of microbial mats may derive mainly from bacterial sources⁷ including photosynthetic bacterial input. In such situations⁸, bacterial markers and the bulk TOC have similar, very heavy, carbon isotope signatures. Thus, Gaia notwithstanding, the jury is still out, and the general conclusion of Hartgers *et al.* that "bacterial biomass may commonly represent only a minor component of total C_{org} in carbonaceous rocks" may be premature.

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HARTGERS *ET AL.* REPLY — Head *et al.* argue that heterotrophic bacterial biomass production in both the water column^{4,5} and surface sediments³ is important. We agree. However, this by no means implies that bacterial carbon will be ultimately preserved.

Organic matter preserved in sediments represents only a very small portion of organic carbon of biomass, the recalcitrant portion such as algaenans⁹ and cutans¹⁰. In fact, its selective preservation is due to the processes mentioned by Head *et al.* operating in the water column and sediments up to 800 metres below sea floor. Parkes *et al.*³ convincingly demonstrated that the uncharacterized portion of the TOC (non-protein, non-carbohydrate, non-lipid) increases to 80% at 10 m depth in sediments of the Peru Margin. The authors suggested that this unsaponifiable, macromolecular material represents 'bacterial necromass'. The material thus far resisted chemical characterization.

In a more recent paper, Parkes and co-workers¹¹ provide evidence that "bacterial necromass" is a good substrate for other bacteria. This implies, in our view, that bacterial carbon can be recycled as efficiently as the primary photosynthate and is, thus, ultimately completely remineralized if no recalcitrant carbon is present. For example, Saddler and Ward-

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2. Kinlen, L. J. *Lancet* **336**, 577-582 (1990).

3. Kinlen, L. J. & Hudson C. *Br. med. J.* **303**, 1357-1362 (1991).

4. Kinlen, L. J., Hudson, C. & Stiller, C. *Br. J. Cancer* **64**, 549-554 (1991).

5. Kinlen, L. J. *et al. Br. med. J.* **306**, 743-748 (1993).

6. Langford, I. *Soc. Sci. med.* **33**, 435-440 (1991).

7. Kinlen, L. J. *Br. J. Cancer* **71**, 1-5 (1995).

8. Kinlen, L. J. & John, S. M. *Br. Med. J.* **309**, 1197-1202 (1994).

9. Wolff, S. P. *Nature* **349**, 23 (1991).

law¹² demonstrate that bacterial lipopolysaccharides (LPS) are degraded very rapidly. A substantial bacterial contribution to C_{org} in petroleum source beds can, thus, only be expected if bacteria contain recalcitrant constituents or if remineralization is cut short by temperature, removal of necessary micronutrients, or some similar factor.

So far, the presence of recalcitrant bacterial components in sediments has not been shown, despite the preliminary data concerning the presence of polar resistant organic material in a specific group of pathogenic bacteria⁶. The lack of preserved organic matter in ancient stromatolites derived from bacterial communities in contrast to their contemporary equivalents indicates that such recalcitrant bacterial components are not important. Further, independent carbon isotope analyses of pyrolysates of kerogens of diverse origin are pertinent for two reasons. First, they indicate that contributions from 'hopane-synthesizing bacterial' (cyanobacteria, heterotrophic and methanotrophic bacteria) are minor¹³. Second, they indicate that contributions from resistant algal biopolymers are dominant¹.

In our paper, we concluded¹ that "net contributions of bacterial biomass are

often small" and acknowledged "the undoubted importance of bacterial reworking of sedimentary organic matter". We have avoided any "sweeping generalizations", but we do recommend a sweeping re-evaluation of the belief that bacteria are quantitatively important sources of organic carbon in carbonaceous sediments.

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considered extinct by Rabor survive at Tabunan, as well as the four taxa he found extant⁶. So seven of Cebu's endemic birds survive, twice the number predicted by the species - area relationship. Does this support Budiansky's views that such theoretical predictions are incorrect, and that deforestation does not cause species extinctions?

It does not. Cebu's remaining endemic birds survive in only 15 km² of forest. The latest Red Data Book⁷ lists the island's two endemic species, the Cebu flowerpecker and the black shama (*Copsychus cebuensis*), as 'threatened'. The same criteria⁷ indicate that we should also consider Cebu's five extant endemic subspecies to be 'threatened'. Thus all seven of Cebu's remaining endemic taxa have at least "a high risk of extinction in the medium-term"⁷. This is considerably more serious than the prediction of the species - area relationship that 3.3 species should survive. So Cebu's endemic birds are indeed "committed to extinction"¹. Our discoveries thus herald both good and bad news.

The good news is that there is still hope, even for species written off as extinct like the Cebu flowerpecker. If this rediscovery is possible, surely other 'extinct' species survive elsewhere. The bad news is that we have no breathing space. To save the Cebu flowerpecker and the island's other endemic taxa will require considerable effort. The Philippine Wetland and Wildlife Conservation Foundation Inc. has initiated a project for conservation on Cebu, but it is very short of money. Unless this situation changes in the immediate future, the Cebu flowerpecker will rejoin the list of birds that have become globally extinct, with no hope of rediscovery.

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Extinction and conservation on Cebu

SIR — Heywood *et al.*¹ argue that predicted extinction rates are higher than those observed because of the time lag before we lose species "committed to extinction". Budiansky² suggests instead that the predicted extinction rates are "simply wrong". Our ornithological fieldwork on the island of Cebu, in the Philippines, supports the argument of Heywood *et al.*



Very little rainforest remains in the Philippines.

Cebu retains 15 km² of dipterocarp forest, 0.3% of its original cover³. In the 1950s, Rabor⁴ failed to record nine of the ten bird taxa then considered endemic to Cebu. He concluded that deforestation had caused the extinction of these birds. Dickinson *et al.*³ considered an additional four taxa to be endemic, of which three are extant. Nevertheless, Cebu appeared to be a textbook application of the species-area relationship to predict extinctions following habitat destruction⁵. We can rewrite $S = c(A)^{0.25}$, where S is the number of taxa, A the area and c a constant, as $S_{new} = S_{original} (A_{new}/A_{original})^{0.25}$. For Cebu, $S_{new} = 14(15/5,088)^{0.25} \approx 3.3$, matching Rabor's finding that four out of 14 endemic taxa had survived.

In 1992, we discovered the Cebu flowerpecker (*Dicaeum quadricolor*), considered extinct since 1906 (ref. 3) in a tiny (2 km²) forest patch at Tabunan⁶. We have also found that two of the subspecies

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