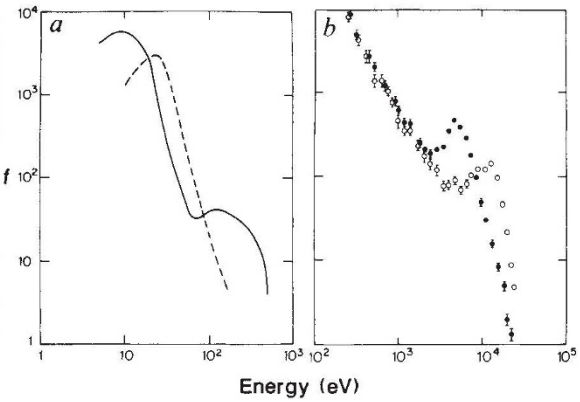

a, Electron velocity–space densities, *f* (relative scale), as functions of energy, in the magnetosheath of Mars (solid curve) and in the solar wind upstream from the planet (dashed curve), derived from measurements made by Phobos 2 on 1 February 1989. *b*, Electron velocity–space densities (in units of km^{-6} s^3), as functions of energy, observed at the centre (open circles) and edge (solid circles) on an electron stream producing a terrestrial auroral arc traversed by Skylark rocket SL1122 on 30 October 1973. The similarity with the martian magnetosheath distributions in *a* is striking and suggests to us that the same electrostatic-wave acceleration is responsible.

from the streaming energy of the solar-wind protons observed[5] from Phobos 2 to be retarded and heated at a location reached at 18:25 UT, intermediate between the observations of single- and double-peaked spectra.

Our explanation, that the lower peak is an unchanged property of the original solar-wind distribution and the higher peak is due to acceleration by lower-hybrid waves, is a direct application of a mechanism we have proposed[2,3,6-8] to account for electron acceleration in the terrestrial aurora, where very similar electron distributions can be observed (*b* in the figure), and in other instances of electron energization in space plasmas. The mechanism is of practical value in experimental nuclear fusion devices where the magnetic field of the current carried by electrons accelerated by lower-hybrid waves helps to contain the plasma, and electron energy communicated to ions serves to heat the plasma[9].

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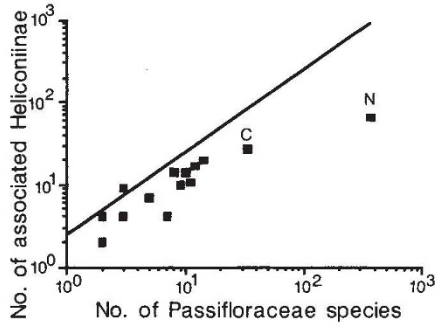
Fewer species

SIR—Erwin[1] obtained 1,200 species of beetle from the canopies of just 19 individuals of one tropical tree species, causing him to suggest that there could be 30 million arthropod species in the whole of the tropics, rather than 1.5 million, the approximate number of species then thought to exist. Stork[2] evaluated Erwin's assumptions and produced a range of values from 7 to 80 million or more species. But I calculate tropical arthropod diversity to be about 6–9 million species.

To produce their estimates, Erwin and Stork had to estimate the proportion of insect species specific to a given tree species. These authors ignored other insects as transients because these insects should be counted as genuine associates of other plants. But this categorization of insects is rather simplistic[2]. Many herbivores feeding on a given tropical plant species also feed on other plants in the same community[3], and insects are often specialists on different plant species in different places. If these insects are categorized as specific, they will be counted more than once in estimates of global diversity because the extrapolation procedure relies on multiplying the number of specific herbivores per plant by the number of plant species.

After eliminating transients, I corrected for the overlap in herbivore faunas between plants. A parameter (x) allows the number of herbivore species supported by a plant community (a) to be estimated from the number of species of herbivore per plant population (b) by the equation $a = x \times b \times c$, where c is the number of plant species in the community. For well-known communities, x can be calculated. For the herbivores of passion vines (*Passiflora*) at a site in Costa Rica (Sirena)[3], there are 30 herbivores for which adequate data exist (a), an average of 11.7 herbivore species per plant (b) and 9 *Passiflora* species (c), so x is 0.28. For the relatively host-specific Heliconiinae butterflies on *Passiflora*, estimates of x for four communities are 0.56 for the Arima Valley, Trinidad, 0.71 for Rincon, Costa Rica, 0.29 for Rio de Janeiro and 0.56 for Corcovado (including Sirena) in Costa Rica[4,5]. The mean x is 0.45. Without this correction, multiplying the number of plant species by the number of herbivores per plant produces an estimate of community diversity that is too high by a factor of about two (1/0.45 = 2.2).



Relationship between the number of Passifloraceae species recorded and the number of Heliconiinae species associated with those plants. Unlabelled points show data for single sites (from refs 4, 5, 8). C, combined data from RIncon, Arima Valley, Rio de Janeiro and Corcovado sites; N, total for neotropics (data from refs 6, 7); line, number of Heliconiinae species expected if a linear projection is made on the basis of the average number of Heliconiinae (2.73) on single *Passiflora* populations.

A parameter (y) that might allow the estimation of approximate global (or continental) diversity (d) from the number of species of herbivore per plant population (b) is given by $d = y \times b \times e$, where e is the world (or continental) number of plant species. Again, this parameter can be calculated for well-known groups. There are about 66 species of neotropical Heliconiinae butterflies[6], and a minimum estimate of the number of Passifloraceae in the American continents is 360 species[7]. From studies of 45 Passifloraceae populations drawn from 33 species[4,5], the average number of species of Heliconiinae per Passifloraceae population is 2.73. These values give an estimated y of 0.067. Without this correction, extrapolation from the number of Heliconiinae species on one Passifloraceae population to those associated with all American Passifloraceae would result in an overestimate by a factor of 15 (1/0.067; see figure). Tentatively, the overestimate can be partitioned into a within-community component of about 2, and a between-community component of about 7 (15/2.2).

Using $y = 0.067$ as a correction factor, I have recalculated diversity from Erwin's data and assumptions, except that I assume beetles to be 20% rather than 40% of tropical arthropod species[2]. This gives a value of 3 million arthropod species in tropical canopies, or 6–9 million if ground arthropods[2] are included.

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