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ECOLOGY

Global maps of soil nematode worms

Accurate estimates of the biodiversity of soil animals are essential for conservation efforts and to understand the animals' role in carbon cycles. Such information is now available on a global scale for nematode worms. SEE ARTICLE P.194

NICO EISENHAUER & CARLOS A. GUERRA

Climate change is affecting biodiversity and the functioning of ecosystems around the globe[1]. Soil organisms are a crucial component of terrestrial biodiversity, and aid human well-being by making contributions in areas such as food security, water purification and carbon storage[2,3]. However, there is uncertainty about how the dynamics of soil biodiversity will change in the future as a result of agricultural intensification and alterations in climate and land use[4]. This is alarming, given the substantial gaps in current knowledge about the global distribution of soil biodiversity[5,6]. Large, worldwide data sets of soil microorganisms and fungi are available, and these have been generated using DNA-based approaches[7,8]. However, no quantitative assessment of soil animals has been undertaken at the global scale. On page 194, van den Hoogen *et al.*[9] now fill this gap by presenting the most comprehensive data set of soil-dwelling nematode worms reported so far.

Nematode worms are tiny (no more than 10 millimetres in length), transparent roundworms that live in films of water in the soil[10] (Fig. 1). They provide a useful subject for studying soil biodiversity because they are so common — their numbers can often exceed 1 million individuals per square metre of soil[11]. Nematodes represent approximately 80% of all the multicellular animals on Earth[11,12], and they have major roles in many ecosystems. In some cases, they have a negative effect, for example some nematodes are plant pests that can cause devastating losses to global crop yields. By contrast, other types can boost plant growth by driving nutrient cycling[10,12].

Van den Hoogen and colleagues assembled data on 6,759 soil samples taken from the top-soil layer of various ecosystems and all continents. The authors analysed the data to determine the numbers and types of nematode present (using microscopy, these groupings were made on the basis of the type of food eaten by a particular nematode, such as plants or fungi[10,11]). Soil nematode communities vary widely over small spatial scales, and this makes it difficult to use observations taken from a particular place to estimate the global nematode population. To overcome this problem, the authors used a machine-learning approach to analyse published and unpublished data to predict global nematode patterns and thereby generate global-level maps of nematode abundance and biomass. The authors estimate that 4.4×10^{20} nematodes inhabit the upper soil layer around the world, an incredibly large number that is comparable in scale to the estimated number of stars in the observable Universe.

"So far, soil animals have been neglected in carbon models."

Biodiversity for vertebrates, invertebrates and plants decreases from the Equator to the poles, and many possible mechanisms underlying this trend have been discussed[13]. By contrast, van den Hoogen and colleagues report the opposite pattern for nematodes: the highest abundance and biomass — indicators of biodiversity — occur in boreal forests (such as conifer forests in snowy landscapes) and tundra regions (cold plains that lack tree growth). This discovery thus challenges the current textbook view of the global distribution pattern of animal diversity. Instead, the authors' data suggest that the global distribution patterns of soil animals are more similar to those of soil-dwelling microbes[6,7].

Van den Hoogen and colleagues also present global estimates of the amount of carbon stored in nematode bodies, as well as estimates of nematode metabolic activity. The authors' projections indicate that nematode

NATURE

50 Years Ago

The steam engine may be dead, but for Emmett connoisseurs there is always the wasp mistblower. This is one possible solution to the problem of getting rid of wasps from tall trees, designed by Drake and Fletcher Ltd … for spraying insecticides to high levels, and tested as part of a research programme by the Forestry Commission. A special "coconut outlet", originally used for palm trees, injects the spray liquid into an air blast. Other methods investigated include rotating sprinklers attached to the tops of individual trees, and a mobile sprinkler which reaches suitable heights with a telescopic mast. Only the mistblower, which is mounted on a tractor, seems feasible for large-scale applications — the respective disadvantages of the other two are a dearth of skilled climbers to install the machinery, and a time-consuming erection process for each operation.
From *Nature* 9 August 1969

100 Years Ago

While collecting information on the use of colour-protection among birds, my attention has been directed to … a very interesting generalisation, viz. that among birds which nest on the moors, seashores, and similar open places, (1) those which have the habit of remaining on their nests when danger threatens generally wear camouflaged uniforms, but their eggs seldom show any signs of colour-protection; while (2) those which are very shy and leave their eggs readily are generally conspicuously coloured, but their eggs are usually camouflaged. Amongst the first class are capercailzie, … wild duck, and bittern; and amongst the shy ones with camouflaged eggs are lapwing, … ring plover, and golden plover.
From *Nature* 7 August 1919

ANDY MURRAY

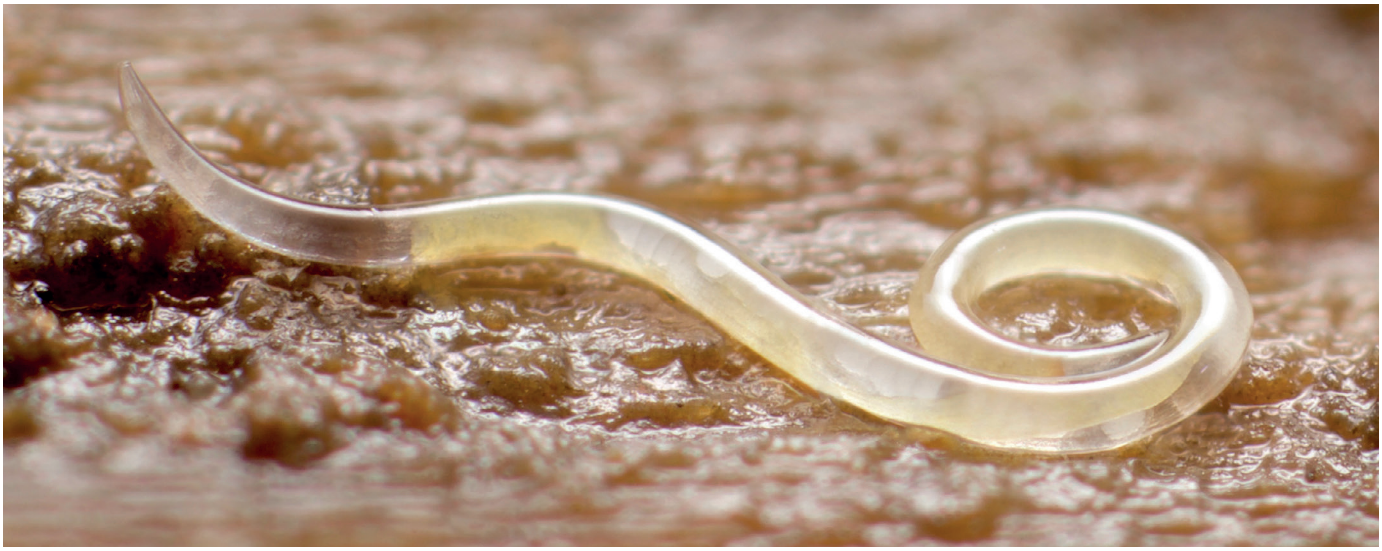

Figure 1 | A nematode worm. Van den Hoogen *et al.*[9] report a comprehensive data set that provides global maps of the abundance and types of soil-dwelling nematodes.

metabolism emits the equivalent of 15% of the current carbon emissions from fossil fuels. This finding has important implications for our understanding of global carbon cycles and potential feedbacks that could affect climate change, given that, so far, soil animals have been neglected in carbon models.

The results presented by van den Hoogen and colleagues suggest that nematodes are abundant in parts of the world that are expected to undergo substantial climate change, such as boreal and tundra regions. The authors highlight the potential threats to these organisms and to the processes that they affect in a changing world. A warming climate might cause a decrease in nematode abundance that will have unknown feedback effects on the emissions of greenhouse gases from the soil and on other ecosystem processes, such as plant infection by pests. It will be essential to gain further insight into the factors influencing other soil animals, such as ants and earthworms, that modulate the environment for smaller organisms, including nematodes[2]. Addressing this will require comprehensive, global sampling and monitoring over time[14].

Although current developments, including this study by van den Hoogen and colleagues, and other studies[7,8], shed light on the state, processes and functions of soil biodiversity, such data might not elucidate the consequences of current and projected global changes. Therefore, beyond plotting global maps of soil biodiversity, it will be essential to understand the direct and indirect effects that factors driving global change will have on soil communities and ecosystems in the future. It will also be important to know whether these effects vary across different types of ecosystem, soil conditions and land-management approach. An improved understanding of the dynamics of soil biodiversity could provide researchers and policymakers with the knowledge needed to determine how vulnerable the animals in soil communities are, and thus enable the development of effective conservation strategies for soil biodiversity[6].

Advances in the past few decades have led to the development of predictive computer models that can be used to better inform policy decisions[15]. Many current policy and strategic documents already include some form of predictive modelling for making informed projections of possible ecological, environmental, social and economic futures[16]. Yet in most large-scale projections relevant to ecology or sustainability, the role of soils and soil communities has been absent. For example, the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services, which is part of the United Nations, produced a global report on the threats to and trends in biodiversity that did not include a single mention of soil-dwelling organisms in the overview summary section[1], and only a few scattered mentions of these organisms in the main document. It would therefore clearly be valuable to have more information about the expected dynamics of soil biodiversity under scenarios of global change.

In the context of international efforts to tackle climate change, such as the Paris agreement[17], and considering the failure to achieve the 2020 biodiversity goals known as the Aichi targets[18], having one of the most dominant parts of terrestrial diversity absent from scientific and political discourse will probably only contribute to the deterioration of soil biodiversity, with unforeseeable consequences for ecosystem sustainability. This issue is even more crucial, considering that initiatives such as the push for global forest restoration[19] might result in substantial changes to the nematode communities in the Northern Hemisphere. Van den Hoogen and colleagues' work is an urgently needed step in the right direction, and provides a foundation on which to develop a deeper understanding of future terrestrial ecosystems. ■

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This article was published online on 24 July 2019.