

Прогресс в понимании структуры и функций почвенных пищевых сетей

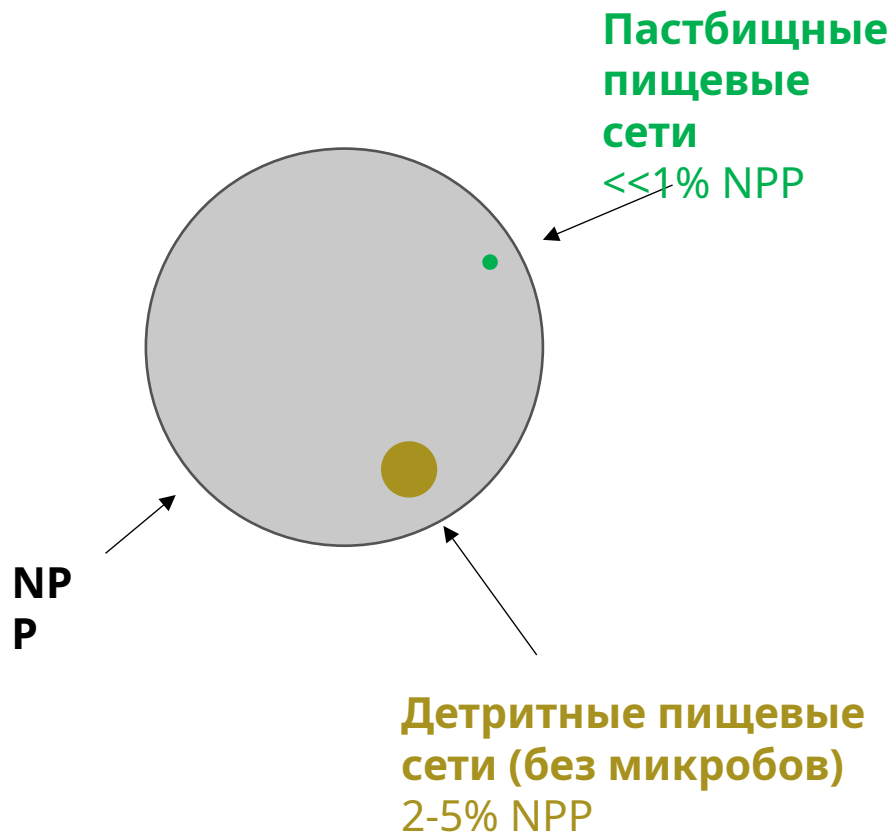
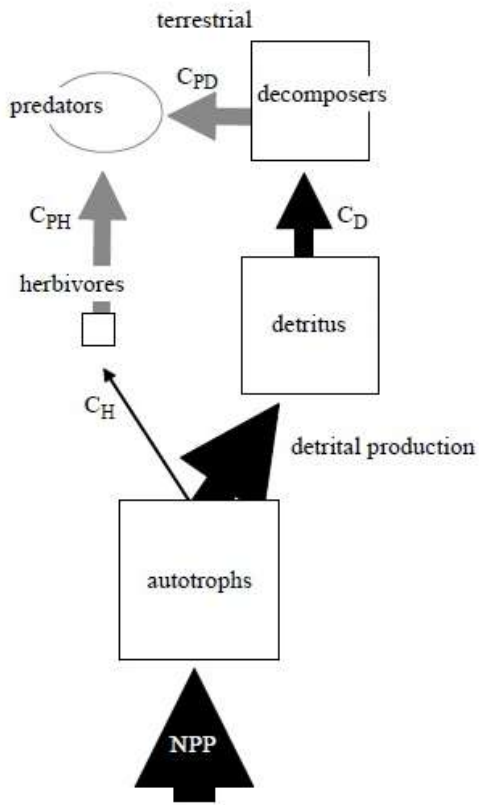


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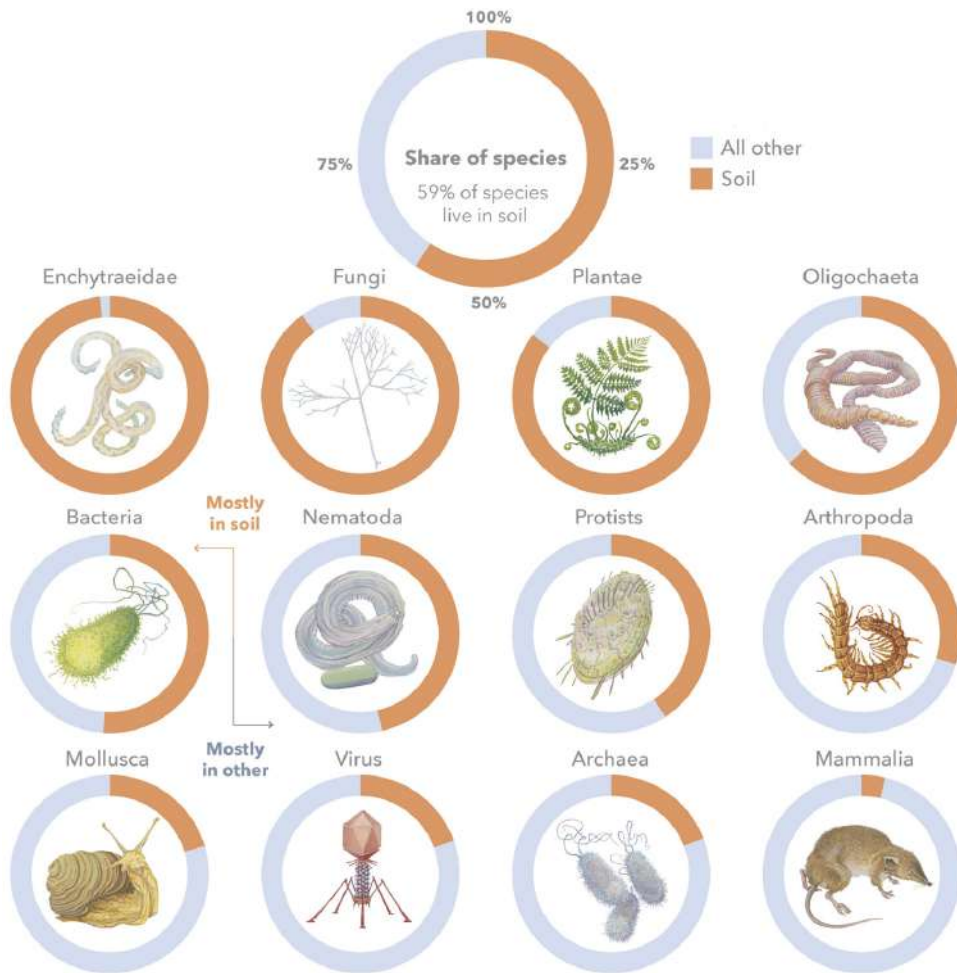


*Екатеринбург
Сентябрь 2026*

Поток энергии



Таксономическое разнообразие

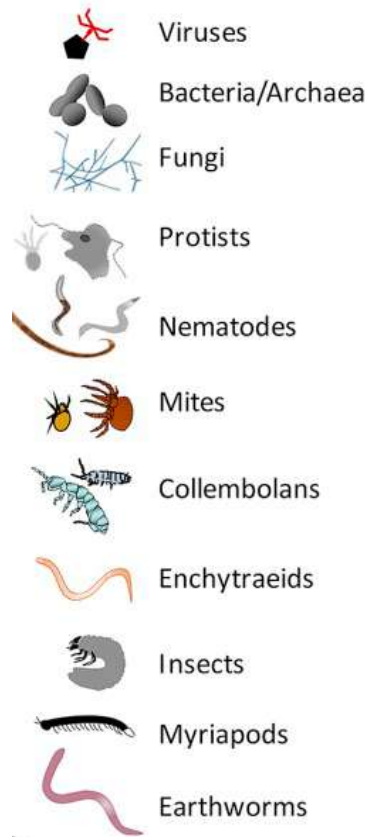
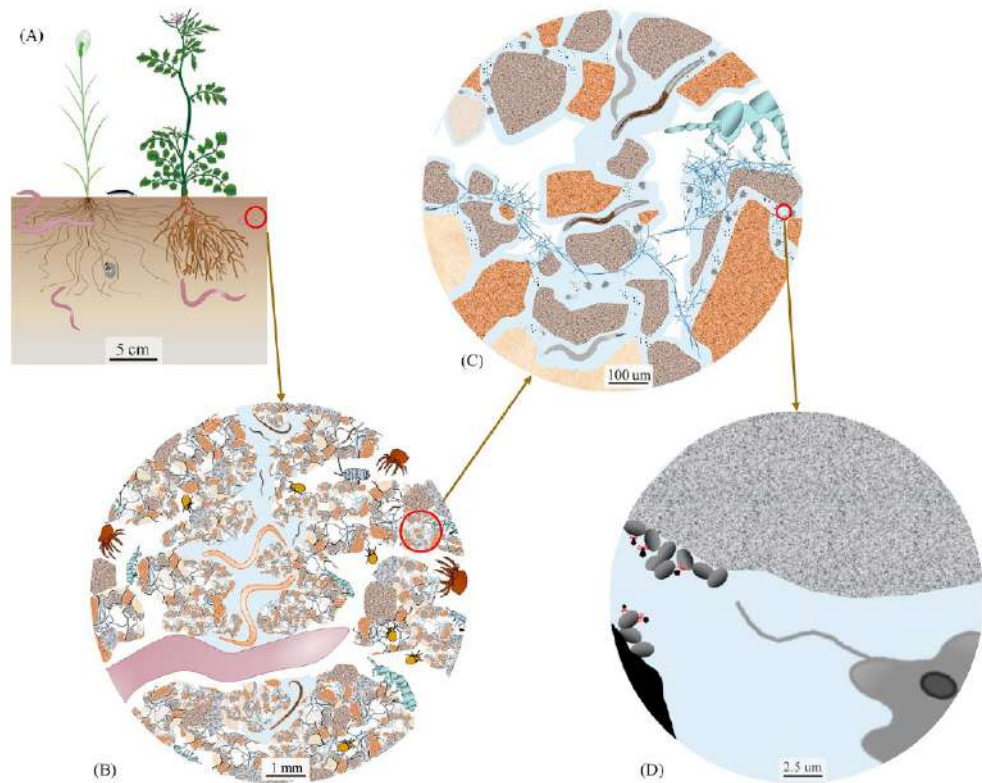


Enumerating soil biodiversity

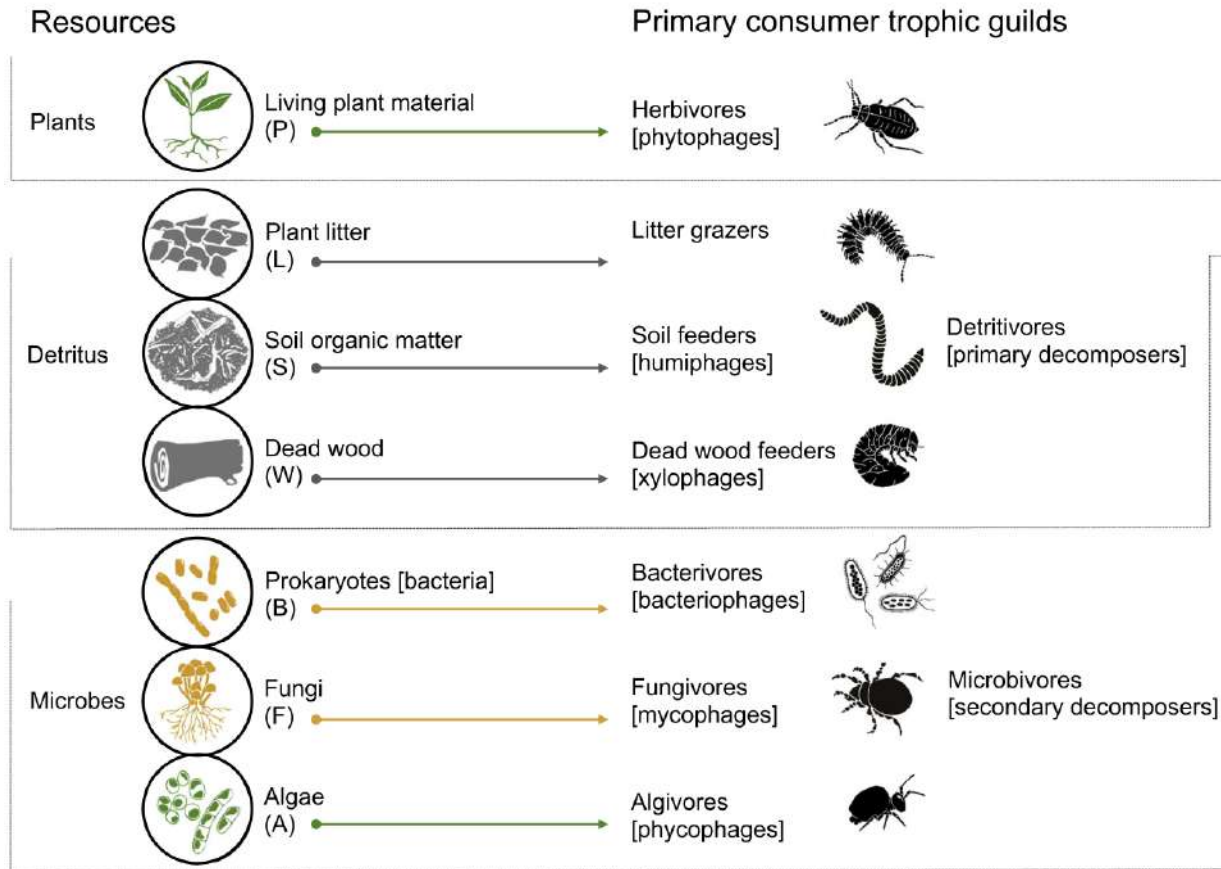
Mark A. Anthony^{ab,1} , S. Franz Bender^{ac} , and Marcel G. A. van der Heijden^{ac,1}

Доля связанных с почвой
видов в ключевых
таксономических группах

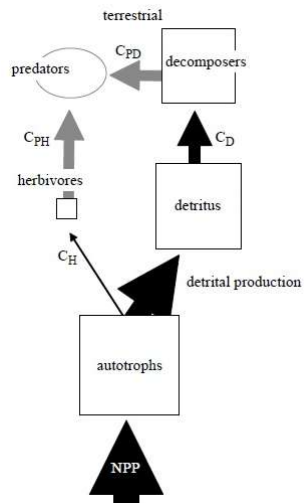
Разнообразие жизненных форм



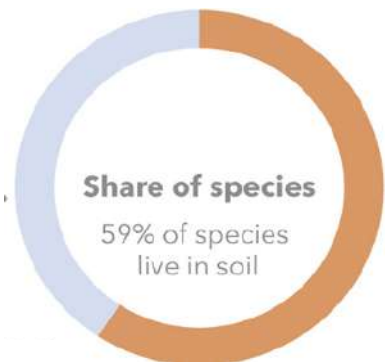
Трофическое разнообразие



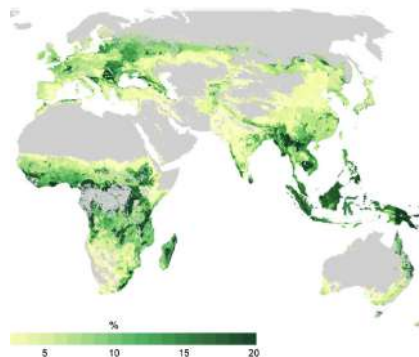
Экосистемный функции



Разнообразие



Хозяйственное значение

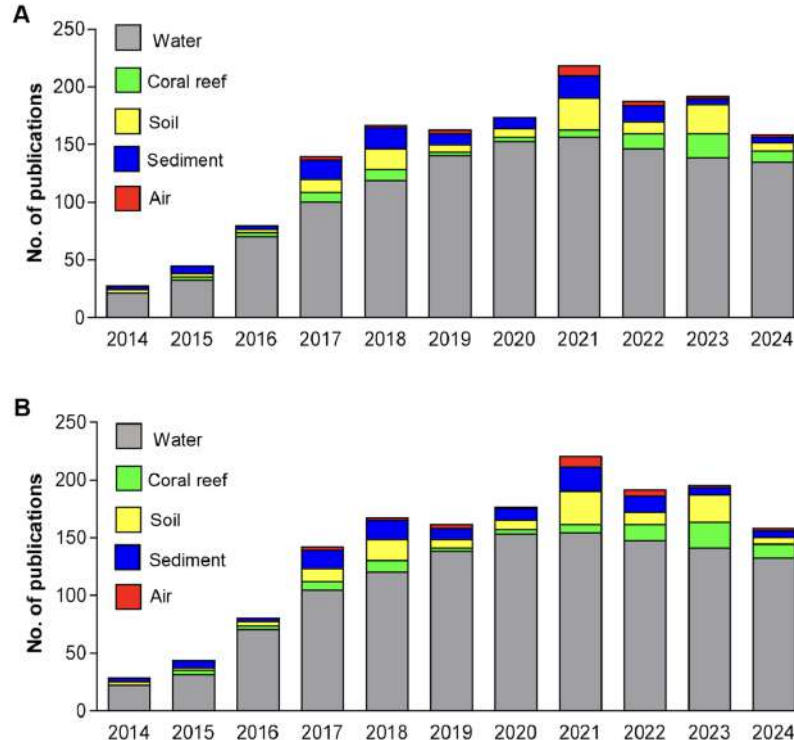


Почти любые аспекты биологии и экологии имеют большое значение, и работы как всегда непочатый край

Новые методы

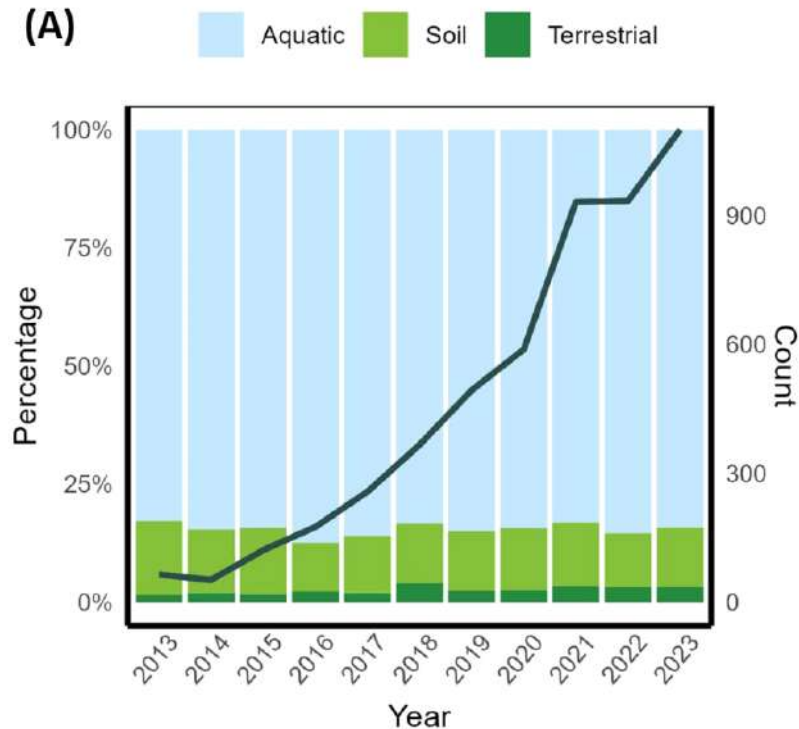
Rishan, S. T., Kline, R. J., & Rahman, M. S. (2025). **Environmental DNA (eDNA) collection techniques across diverse ecosystems: a mini-review of promising new tools for eDNA metabarcoding.** *Environmental Science and Pollution Research*, 32(23), 13566-13577.

Fig. 1 Number of studies using environmental DNA techniques found in Google Scholar (A) and PubMed (B) from January 2014 to May 2024



Метабаркодинг

Cowgill, C., Gilbert, J. D., Convery, I., & Lawson Handley, L. (2025). **Monitoring terrestrial rewilding with environmental DNA metabarcoding: a systematic review of current trends and recommendations.** *Frontiers in Conservation Science*, 5, 1473957.



Валерия Кривошеева
Иван Сотников
Елена Коркина

Но количественные данные – все еще традиционные
методы

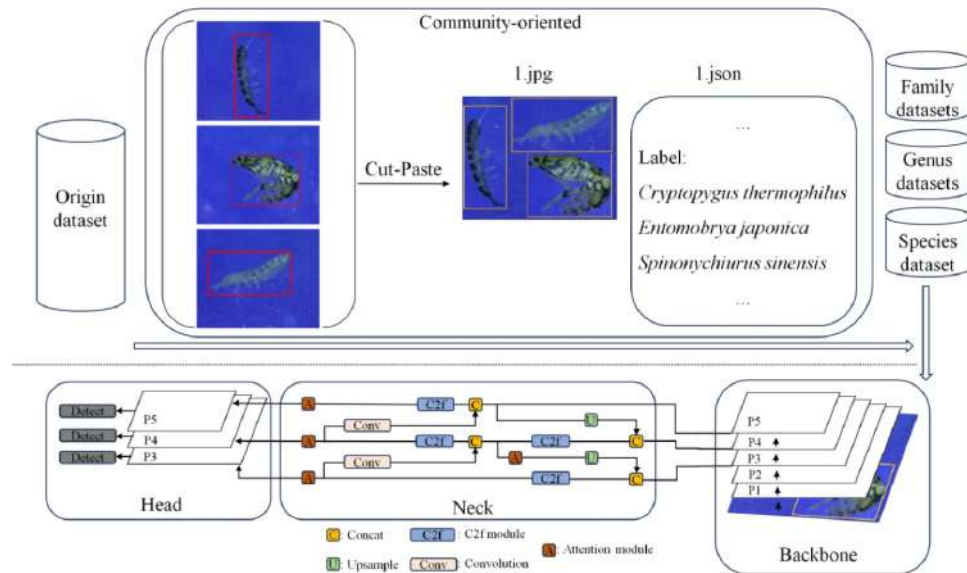




Deep learning method for collembola identification using single species and community combinations images

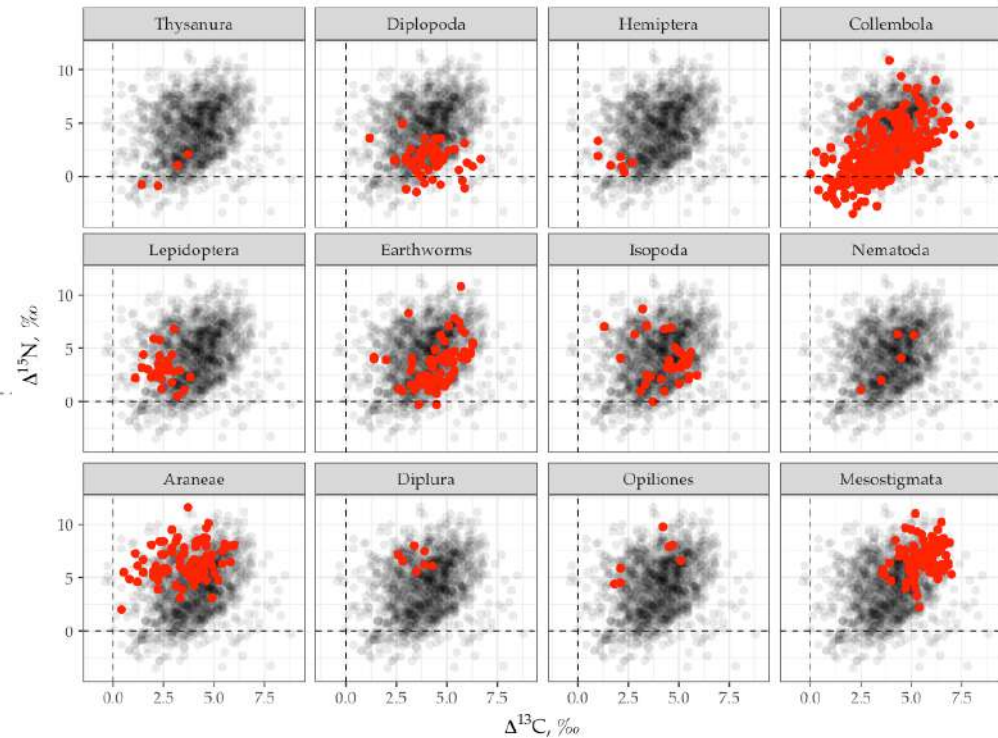
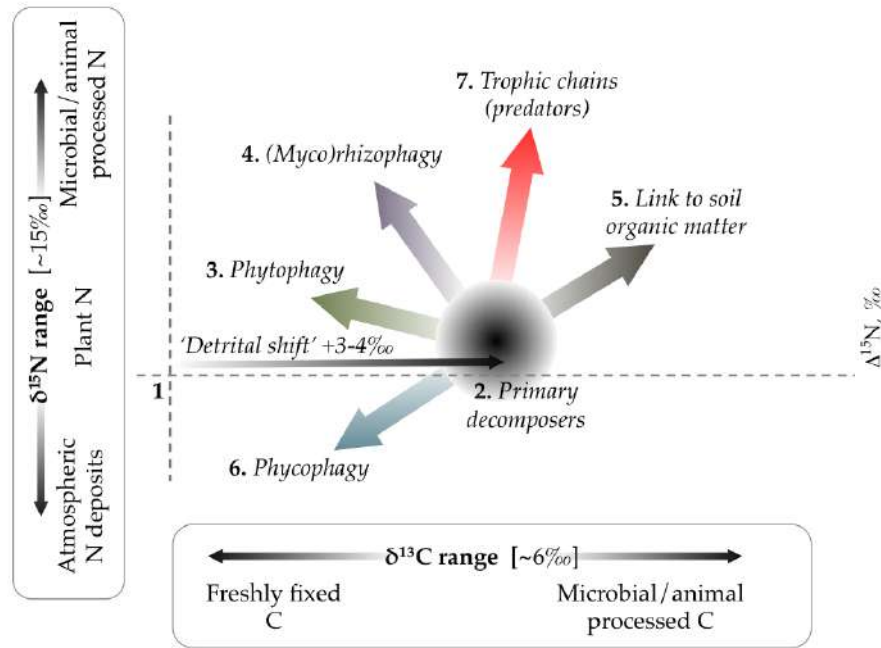
Xiaohao Zhuang¹, Bin Wang², Zhijing Xie², Zhihong Qiao², Jun Feng², Jocelyn E. Behm³, Clément Schneider⁴, Beining Shi¹, Jiayin Zheng¹, Yunyi Gu¹, Yuanyuan Meng¹, Xin Sun^{2,*}, Shengjie Liu^{1,*}

«Наши исследования доказывают, что deep learning имеет огромный потенциал для быстрого и точного определения коллембол, пригодного для решения широких экологических задач».



Uncovering trophic positions and food resources of soil animals using bulk natural stable isotope composition

Anton M. Potapov, Alexei V. Tiunov and Stefan Scheu



BLT

Soil Biology and Biochemistry 183 (2023) 109047

Modification of the bait-lamina test to estimate soil macrofauna and mesofauna feeding activity

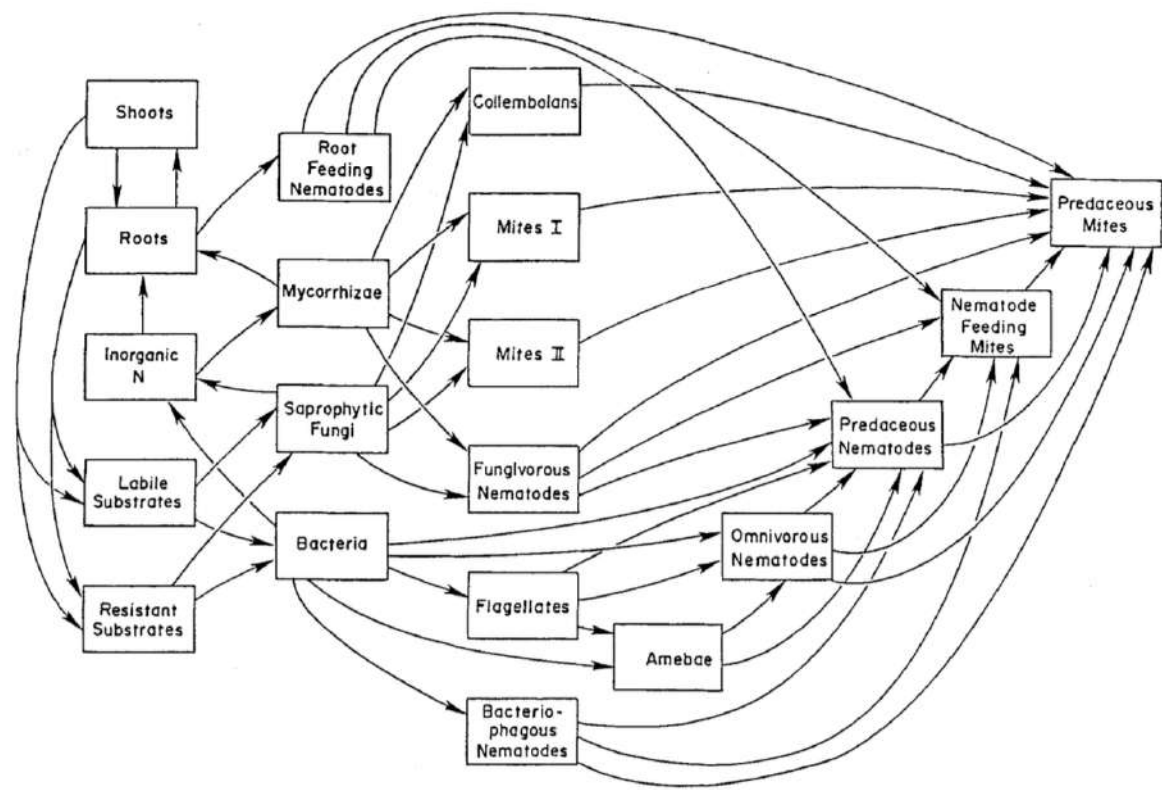
Evgenii L. Vorobeichik^{*}, Igor E. Bergman

Евгений Воробейчик



The detrital food web in a shortgrass prairie*

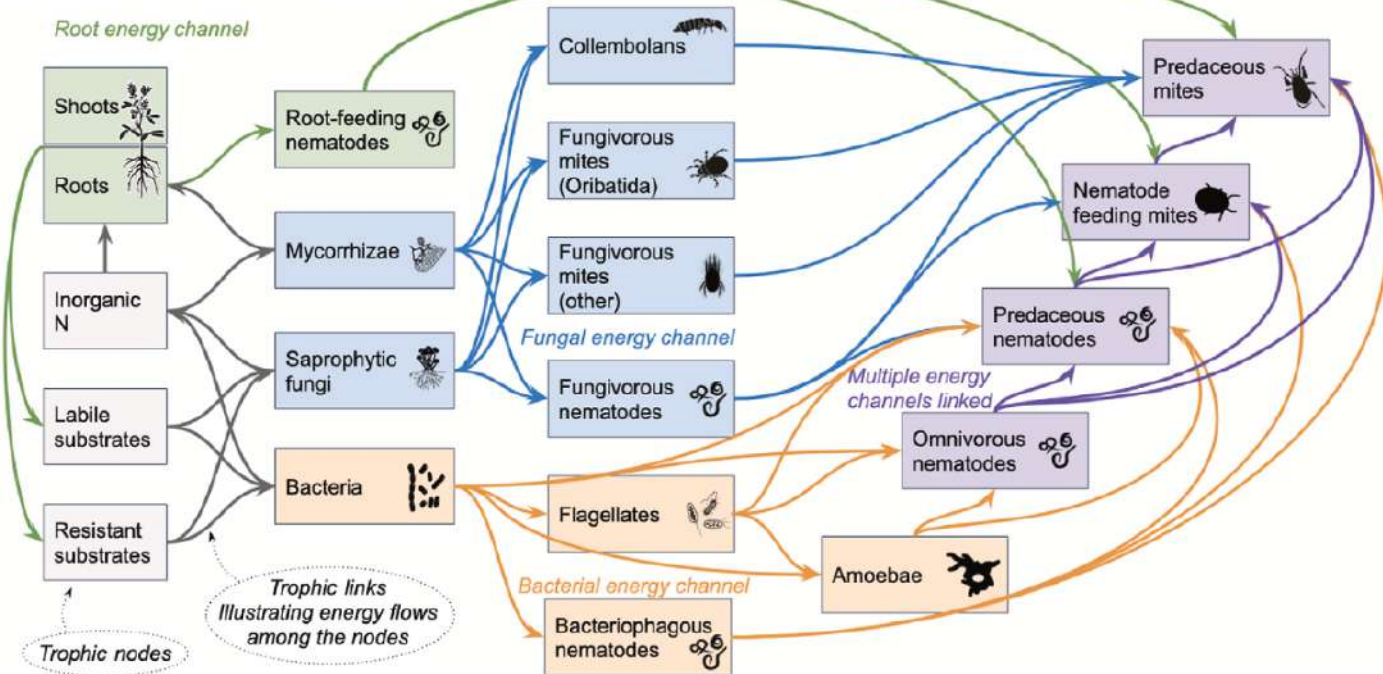
H.W. Hunt¹, D.C. Coleman², E.R. Ingham³, R.E. Ingham³, E.T. Elliott¹, J.C. Moore¹, S.L. Rose⁴,
C.P.P. Reid⁵, and C.R. Morley¹



*Dedicated to the late Prof. Dr. M.S. Ghilarov

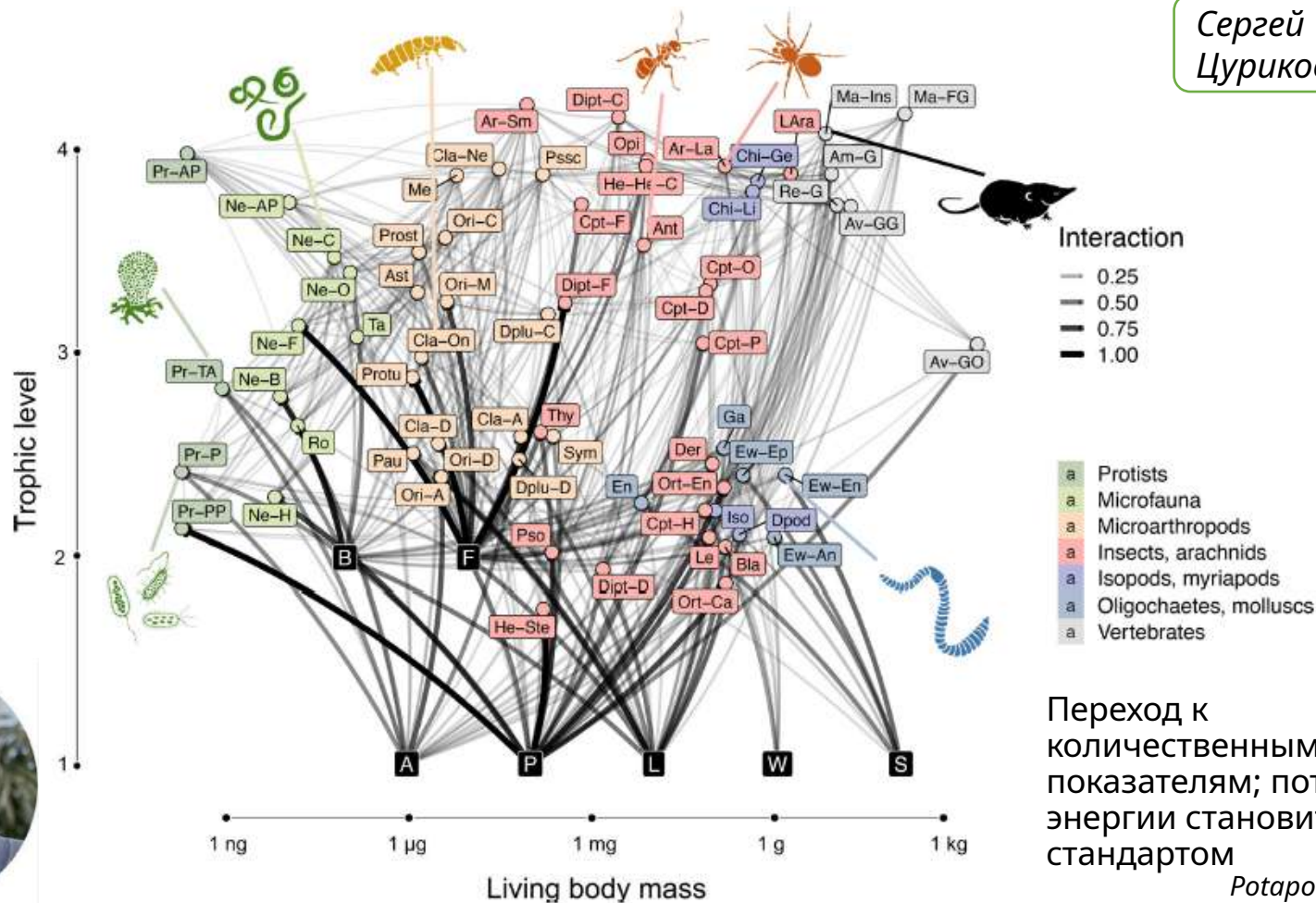
Модели пищевых сетей

Hunt et al. 1987 soil food-web model



Модели пищевых сетей

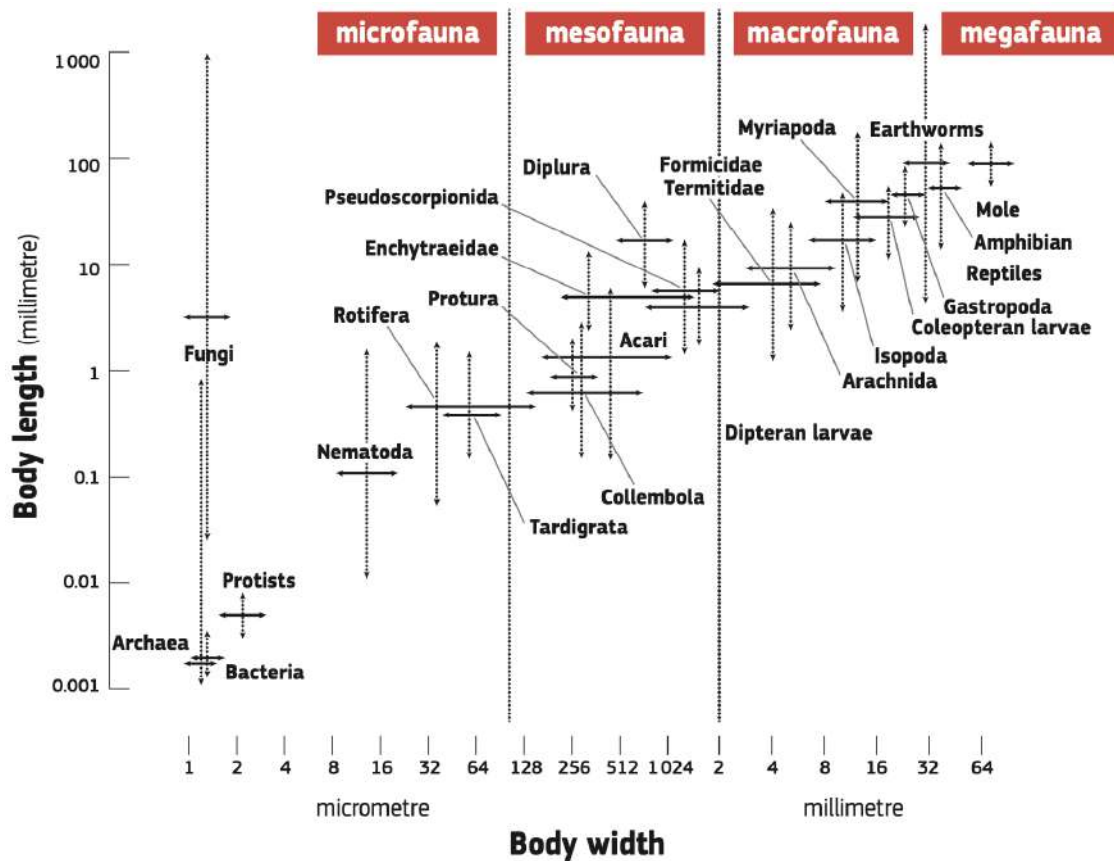
Сергей
Цуриков



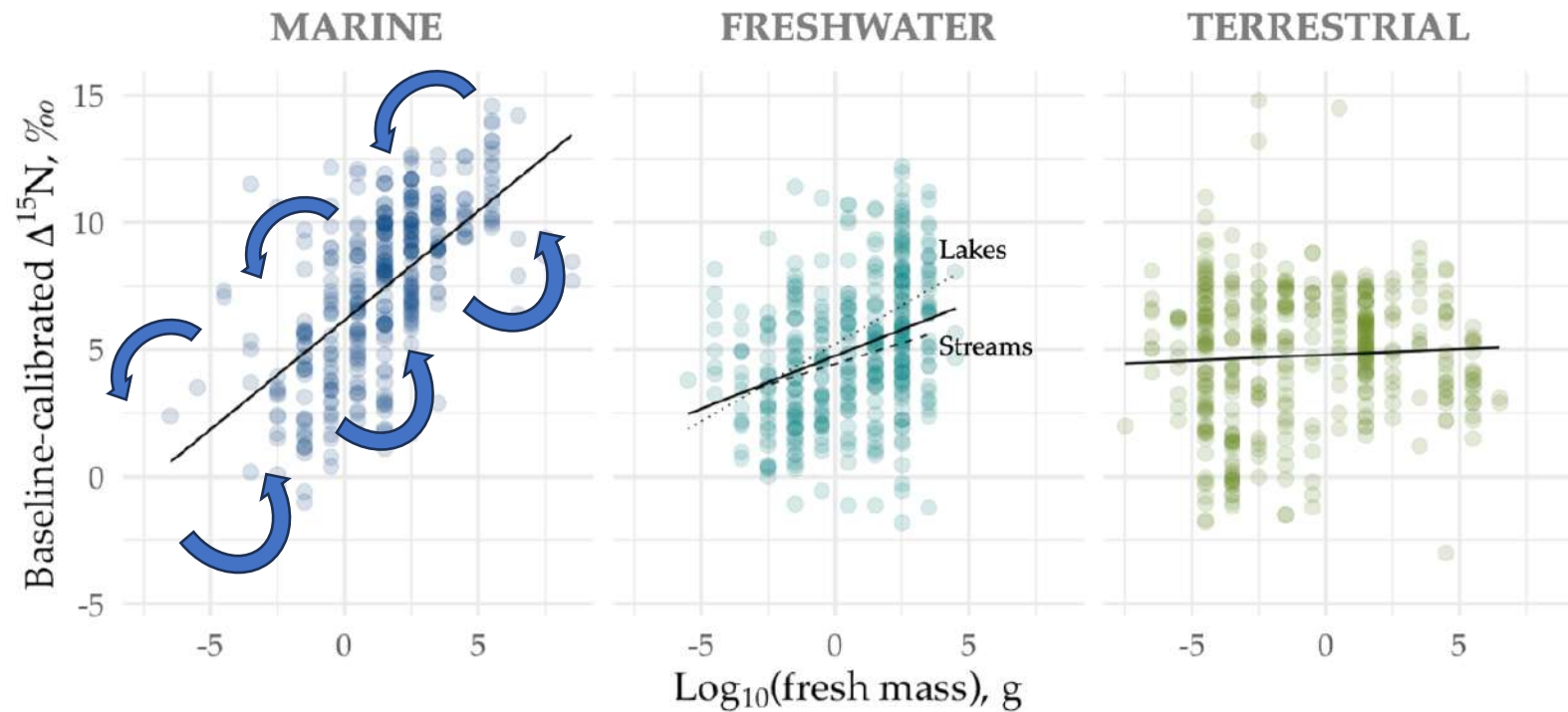
Potapov 2022 Biol. Rev.



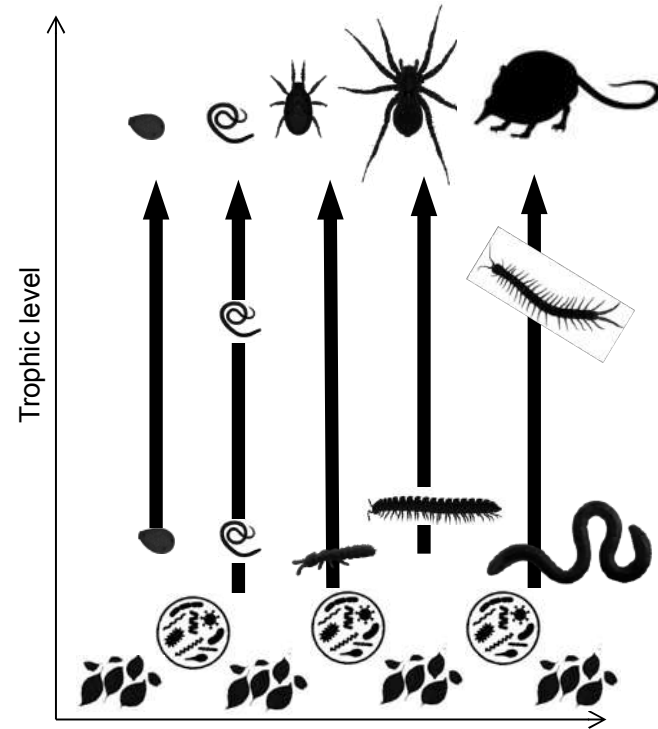
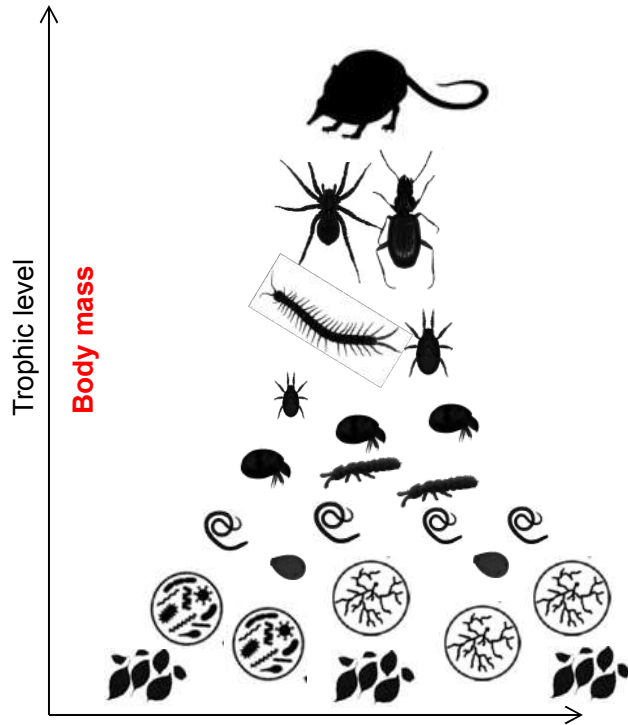
Размер и трофическая позиция



Размерная структура

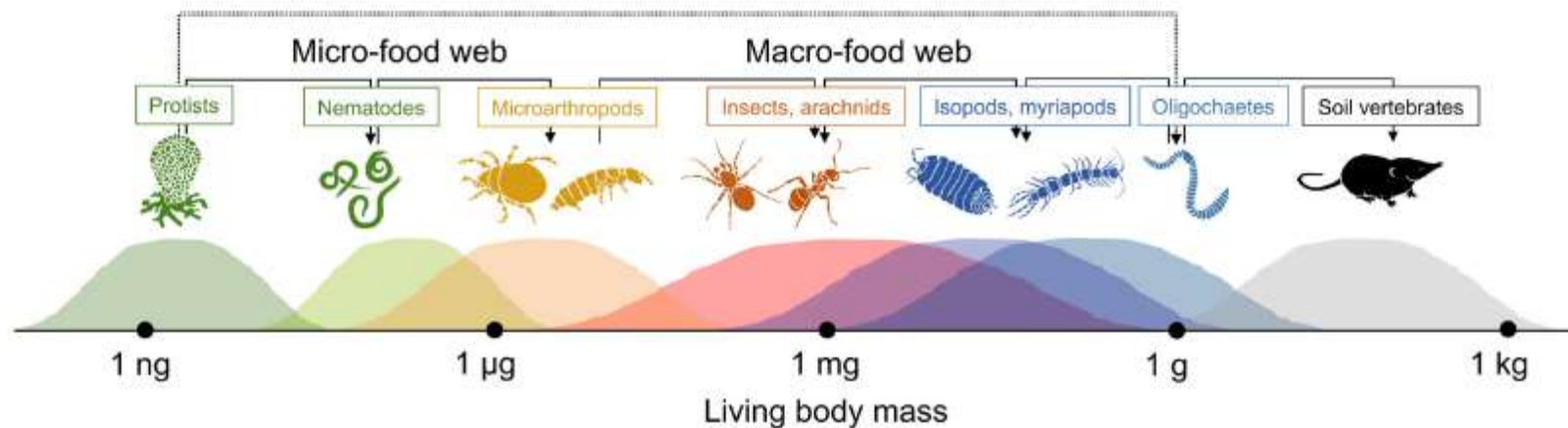


Альтернативные модели



Body mass



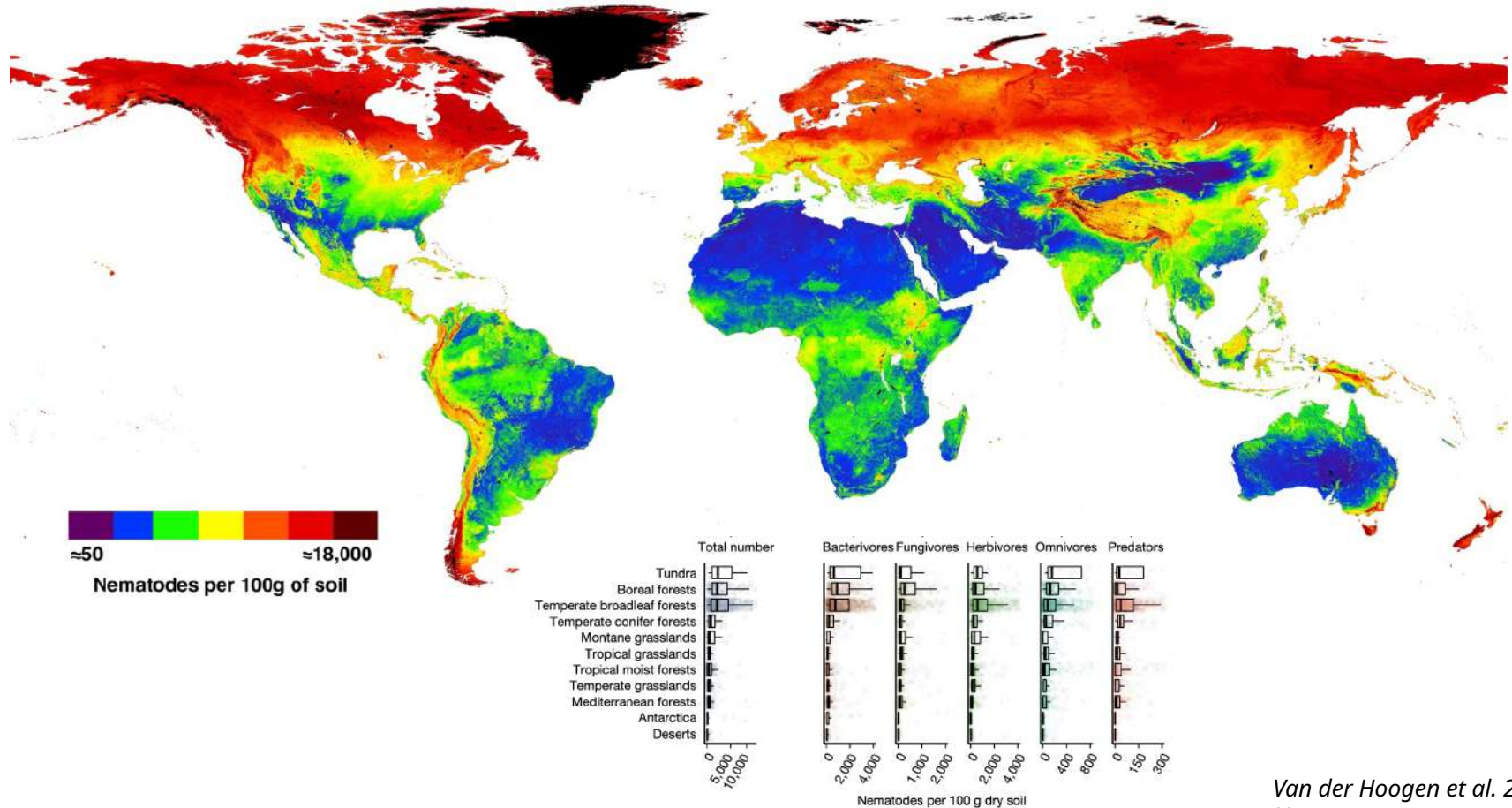


Nutrient mineralisation, trophic specialisation, abundance, turnover rate, dormant stages

Engineering role, mobility, feeding generalism, biomass

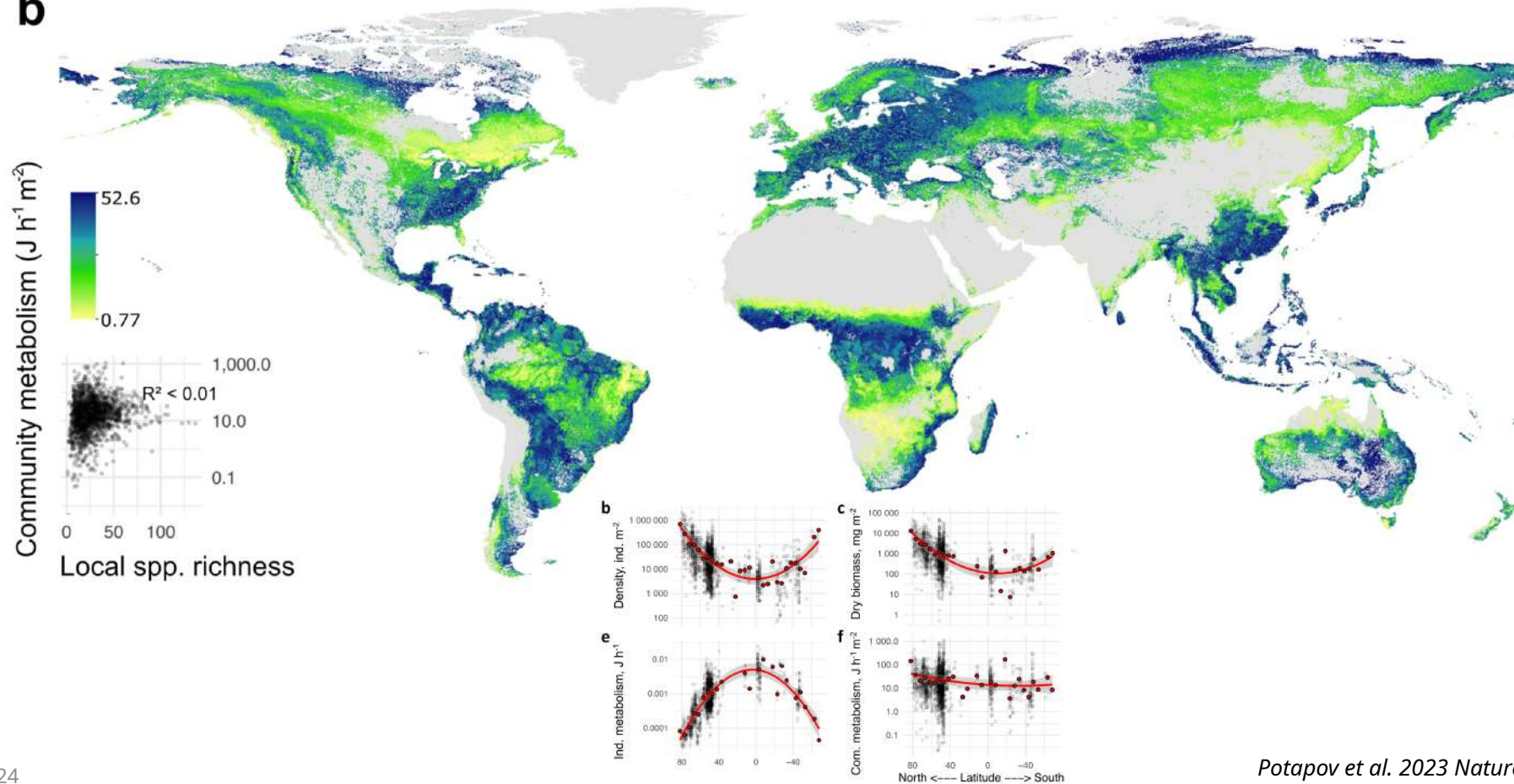
Новые продвижения: глобальные работы

Глобальные оценки - Нематоды



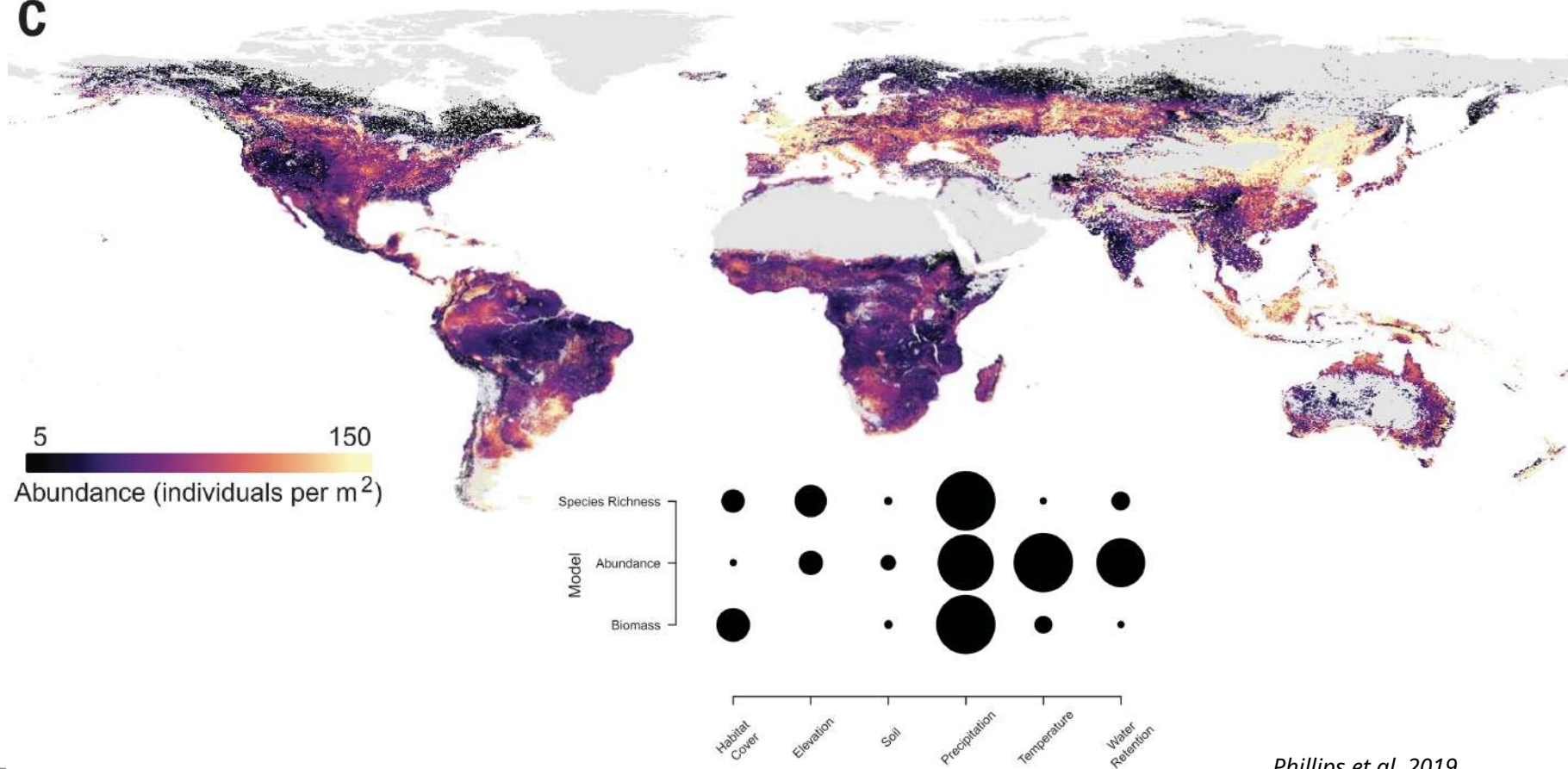
Глобальные оценки - Коллемболы

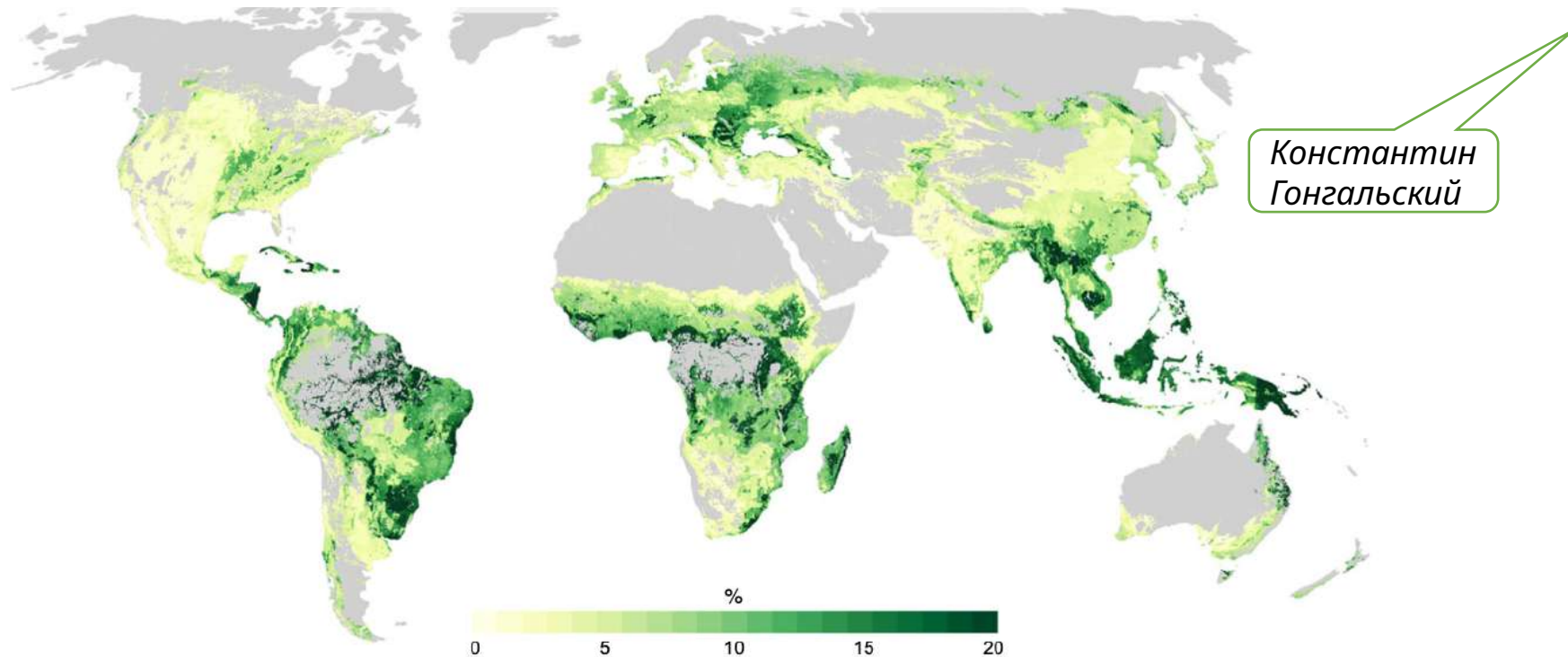
b



Potapov et al. 2023 Nature Comm.

C





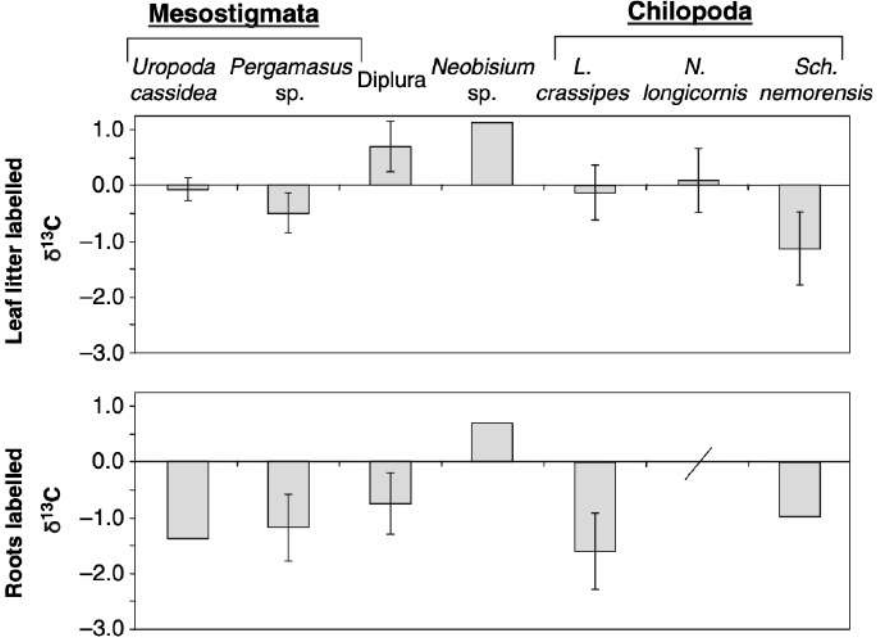
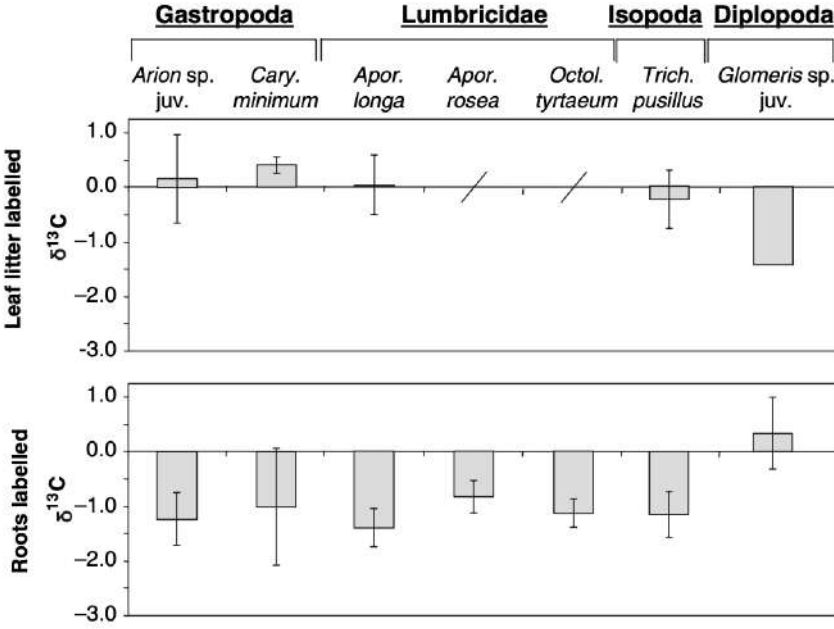
Влияние дождевых червей на повышение урожая зерновых; глобально + 140 000 000 тонн зерна ежегодно (до 5%)

Новые продвижения: корни и микориза

The underestimated importance of belowground carbon input for forest soil animal food webs

Melanie M. Pollierer, Reinhard Langel, Christian Korner, Mark Maraun and Stefan Scheu

Влияние на изотопный состав животных ^{12}C -меченого опада и ^{12}C -меченых живых корней.
Столбики вниз = получение C из опада или из корней.



Plant roots fuel tropical soil animal communities

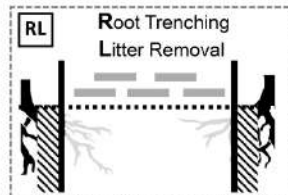
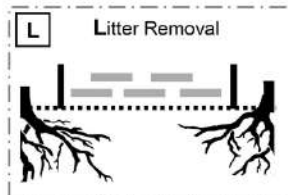
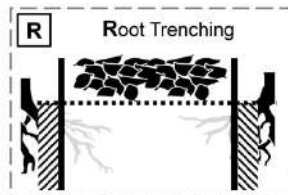
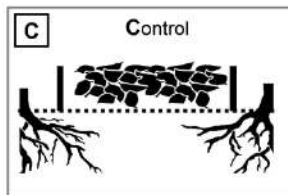
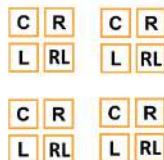
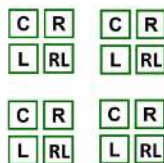
Zheng Zhou¹  | Jing-Zhong Lu¹ | Jooris Preiser¹ | Rahayu Widyastuti²
Stefan Scheu^{1,3}  | Anton Potapov^{1,4,5} 

Алексей Кудрин

Land-use systems

Sites

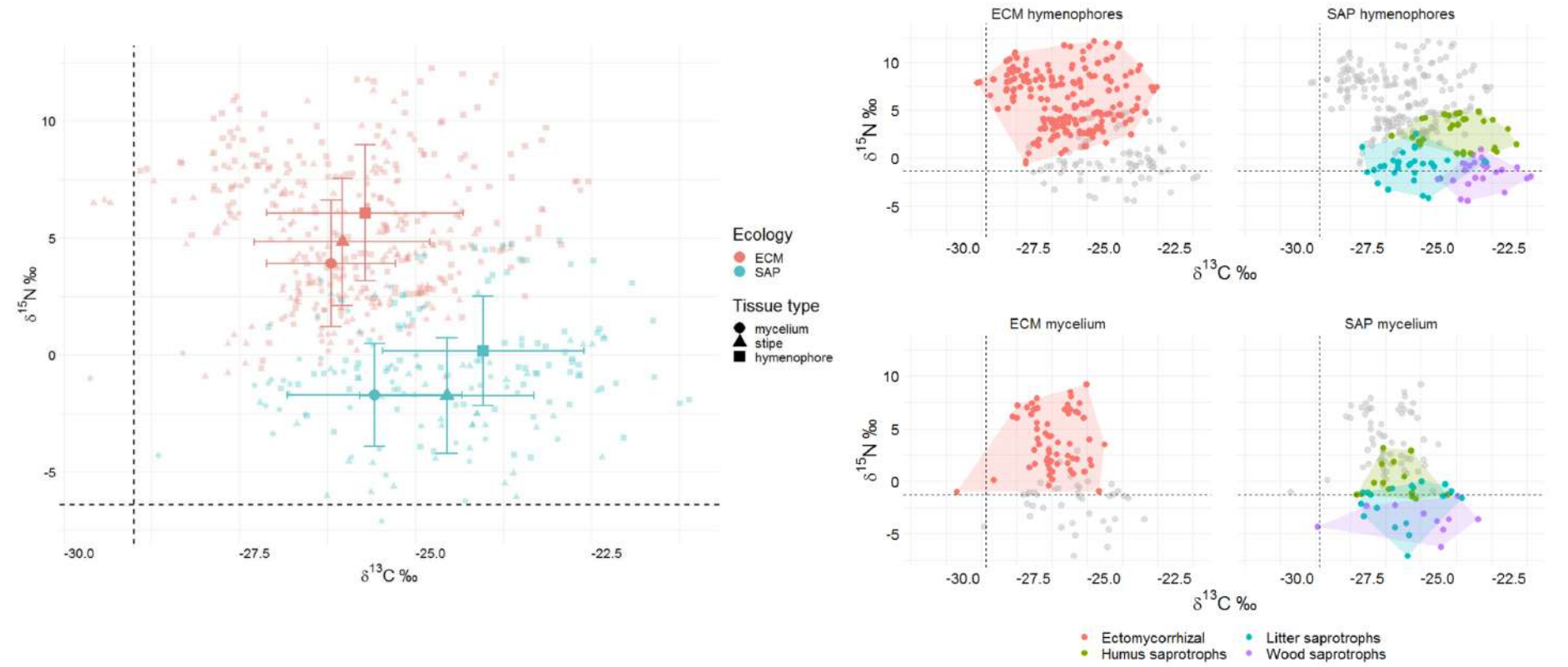
Experimental plots



"...корни так же важны для почвенных животных как наземный опад. Прекращение доступа корней сильнее влияло на животных в подстилке, чем в почве, и привело к общему снижению обилия в дождевом лесу на 42% ..."

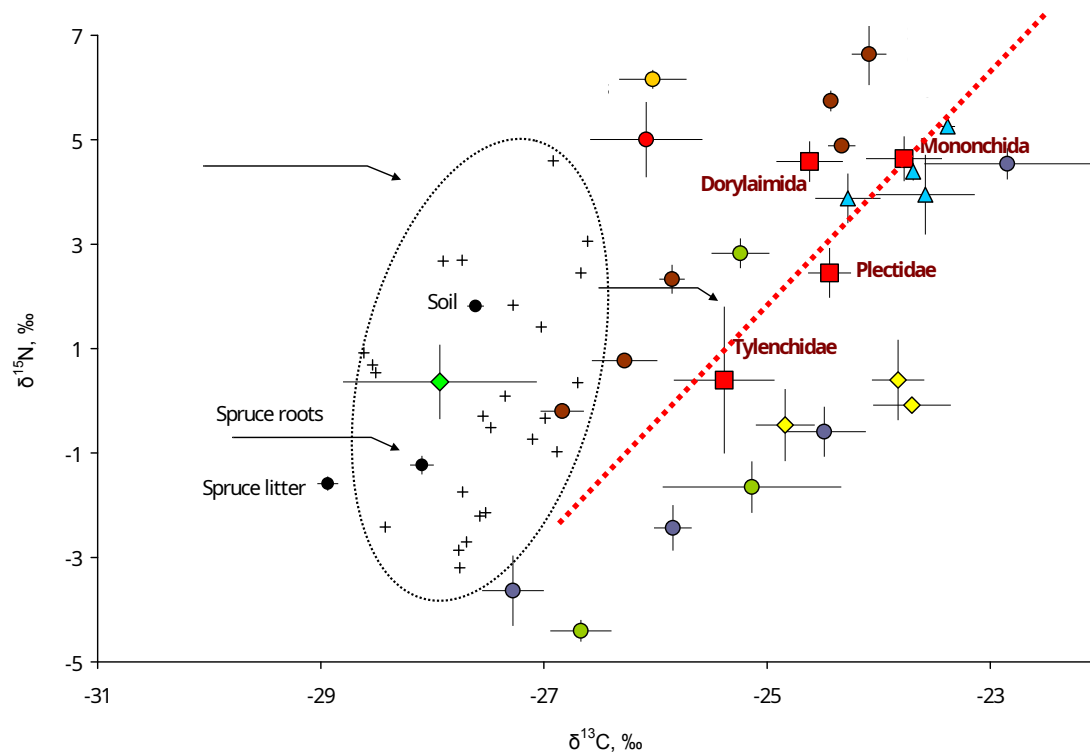
Saprotrophic-mycorrhizal divide in stable isotope composition throughout the whole fungus: from mycelium to hymenophore

A. G. Zuev^{1,2} · A. V. Alexandrova³ · V. A. Litvinskiy⁴ · E. S. Pravdolyubova⁵ · A. V. Tiunov²



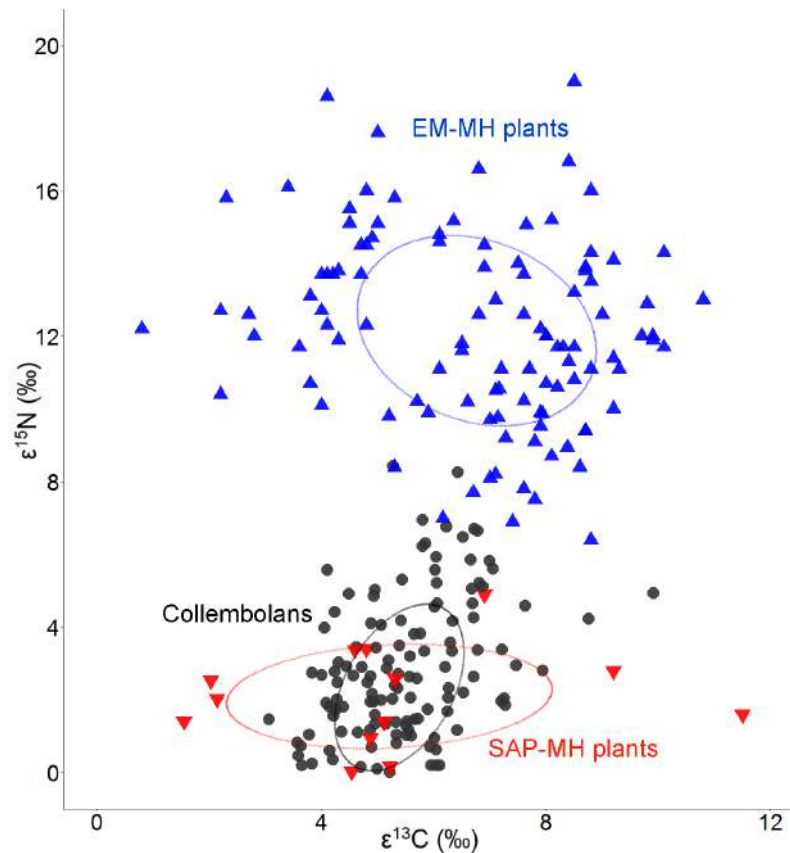
Trophic position of microbivorous and predatory soil nematodes in a boreal forest as indicated by stable isotope analysis

Alexey A. Kudrin ^a, Sergey M. Tsurikov ^b, Alexei V. Tiunov ^{b,*}



Stable isotope composition of mycophagous collembolans versus mycotrophic plants: Do soil invertebrates feed on mycorrhizal fungi?

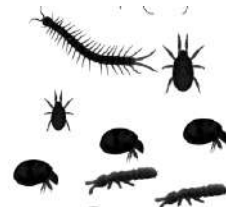
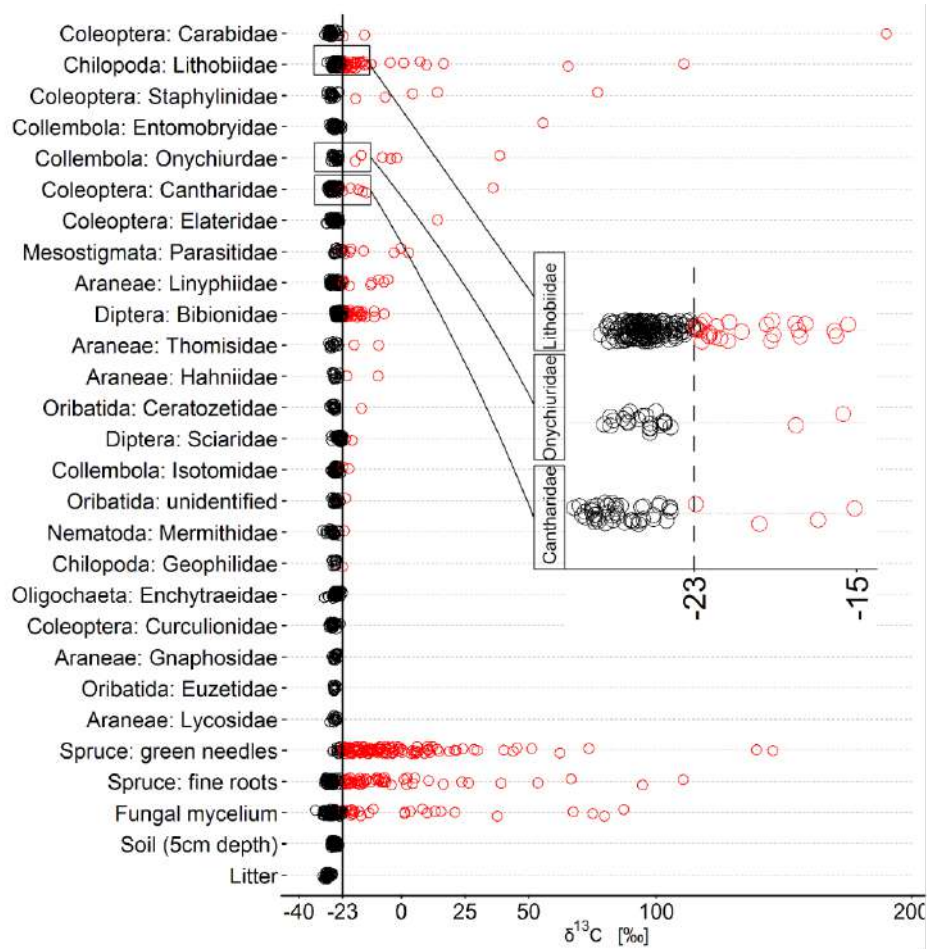
Anton M. Potapov*, Alexei V. Tiunov



Short-term incorporation of freshly fixed plant carbon into the soil animal food web: field study in a spruce forest

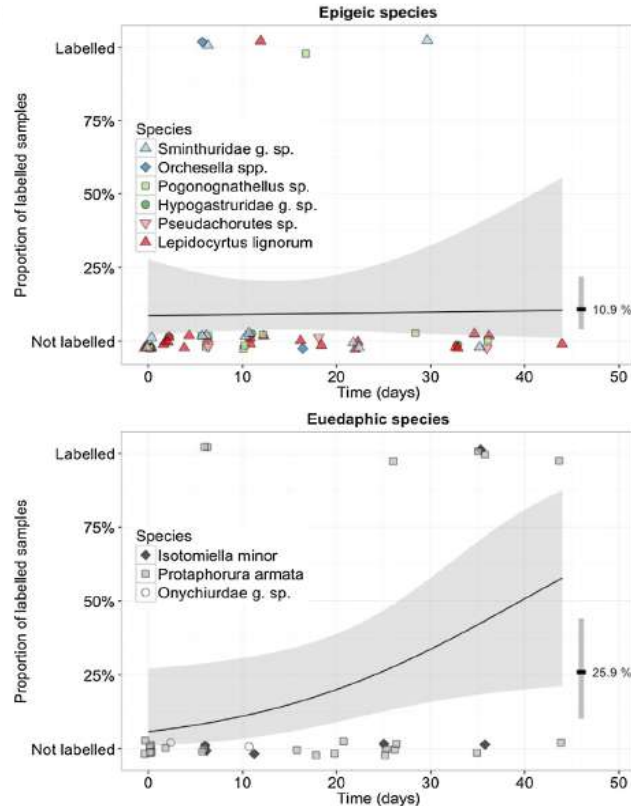
Anton A. Goncharov • Sergey M. Tsurikov

Anton M. Potapov • Alexei V. Tiunov



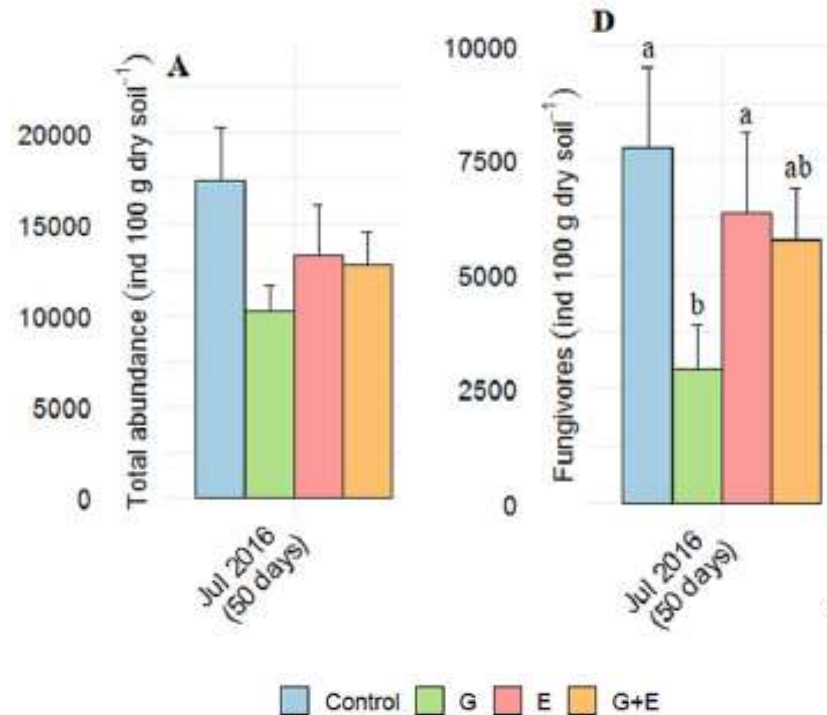
Assimilation of plant-derived freshly fixed carbon by soil collembolans: Not only via roots?

Anton M. Potapov^{a,*}, Anton A. Goncharov^a, Sergey M. Tsurikov^a, Thomas Tully^b,
Alexei V. Tiunov^a



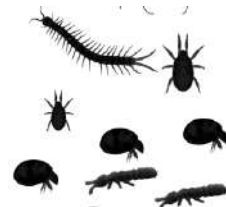
Spruce girdling decreases abundance of fungivorous soil nematodes in a boreal forest

Alexey A. Kudrin^{a,*}, Andrey G. Zuev^b, Anastasia A. Taskaeva^a, Tatiana N. Konakova^a,
Alla A. Kolesnikova^a, Ivan V. Gruzdev^a, Dmitriy N. Gabov^a, Evgenia V. Yakovleva^a,
Alexei V. Tiunov^b

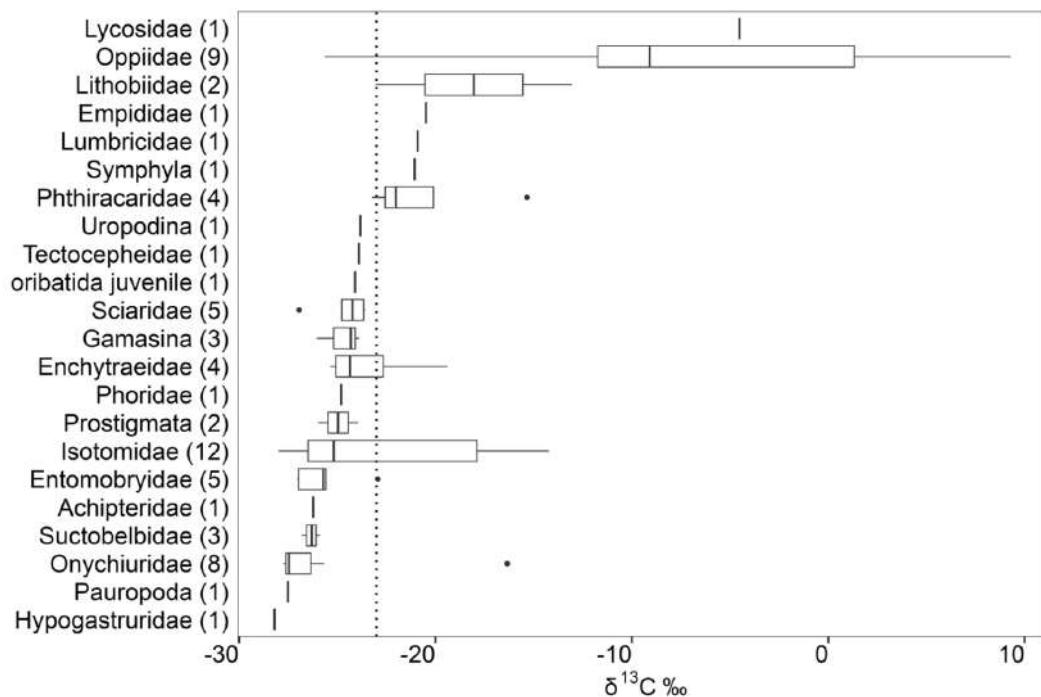


Mycorrhiza-feeding soil invertebrates in two coniferous forests traced with ^{13}C labelling

Andrey G. Zuev¹ · Marina G. Krivosheina¹ · Vladislav D. Leonov¹ · Maarja Öpik² · Martti Vasar² · Anna K. Saraeva³ · Alexei V. Tiunov¹ · Anton A. Goncharov¹

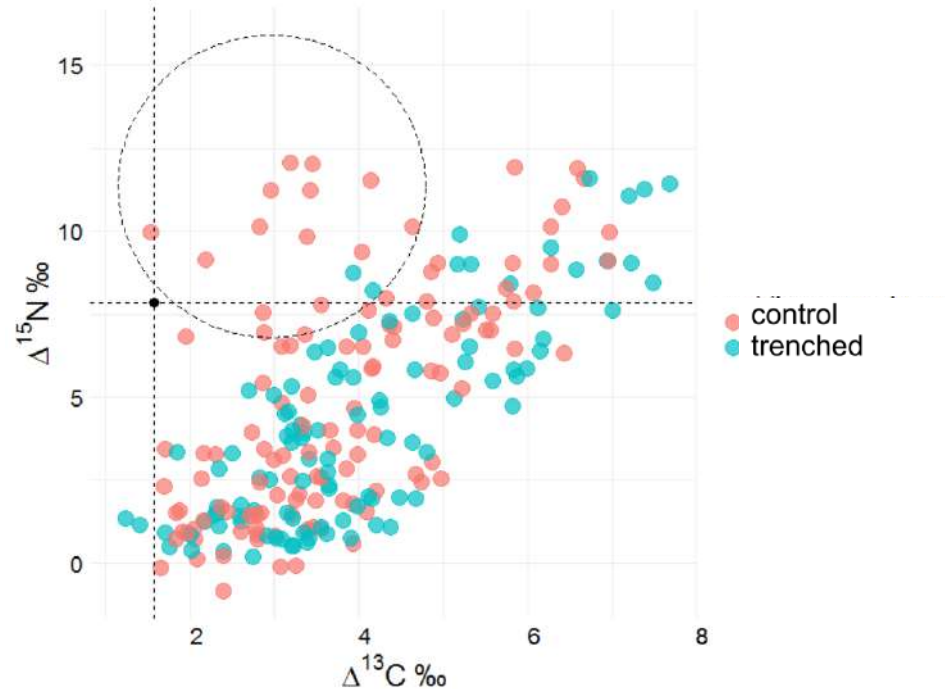


Поступление искусственной ^{13}C метки в ткани почвенных животных. Животные извлечены из почвы, изолированной мелкой сеткой, исключающей доступ непосредственно к корням.



Root trenching and stable isotope analysis uncover trophic links of euedaphic collembola species to mycorrhizal mycelium in pine forests

A.G. Zuev^{a,*}, M.B. Potapov^b, A.V. Tiunov^a, A.K. Saraeva^c

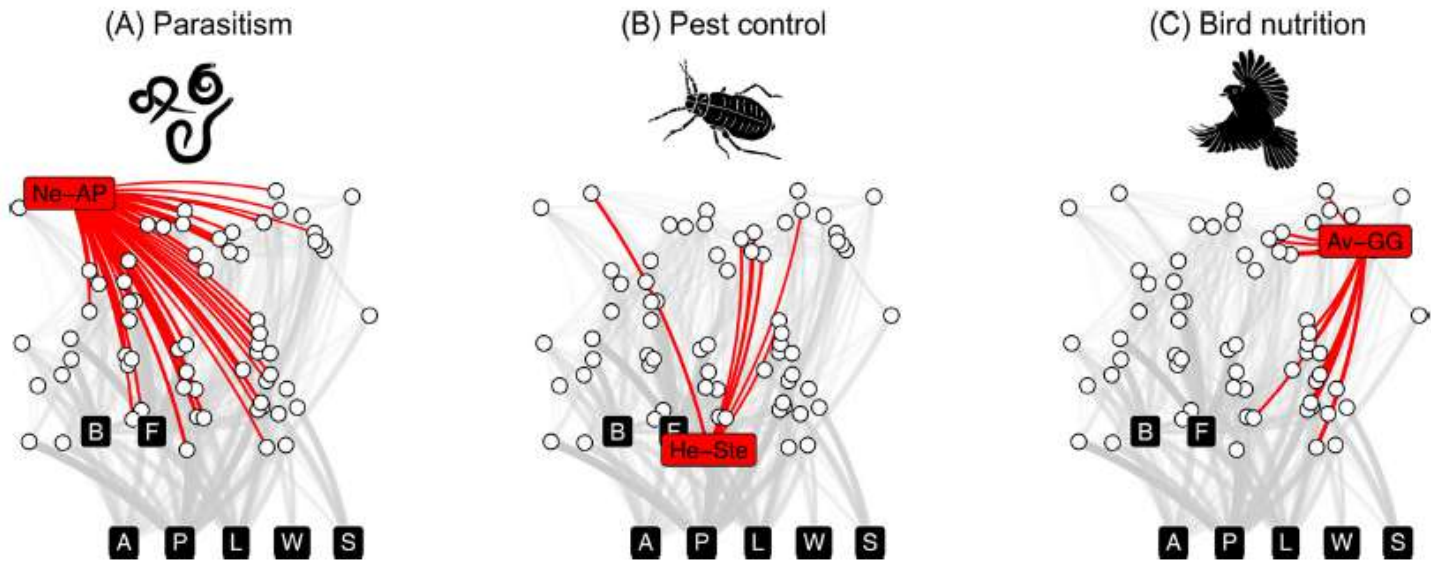


Изотопный состав коллембол в изолированной от корней (голубые точки) и контрольной (красные точки) почве. Эксперимент продолжался три года, но здесь сумма данных за несколько лет.

Новые вопросы: паразиты и болезни

Multifunctionality of belowground food webs: resource, size and spatial energy channels

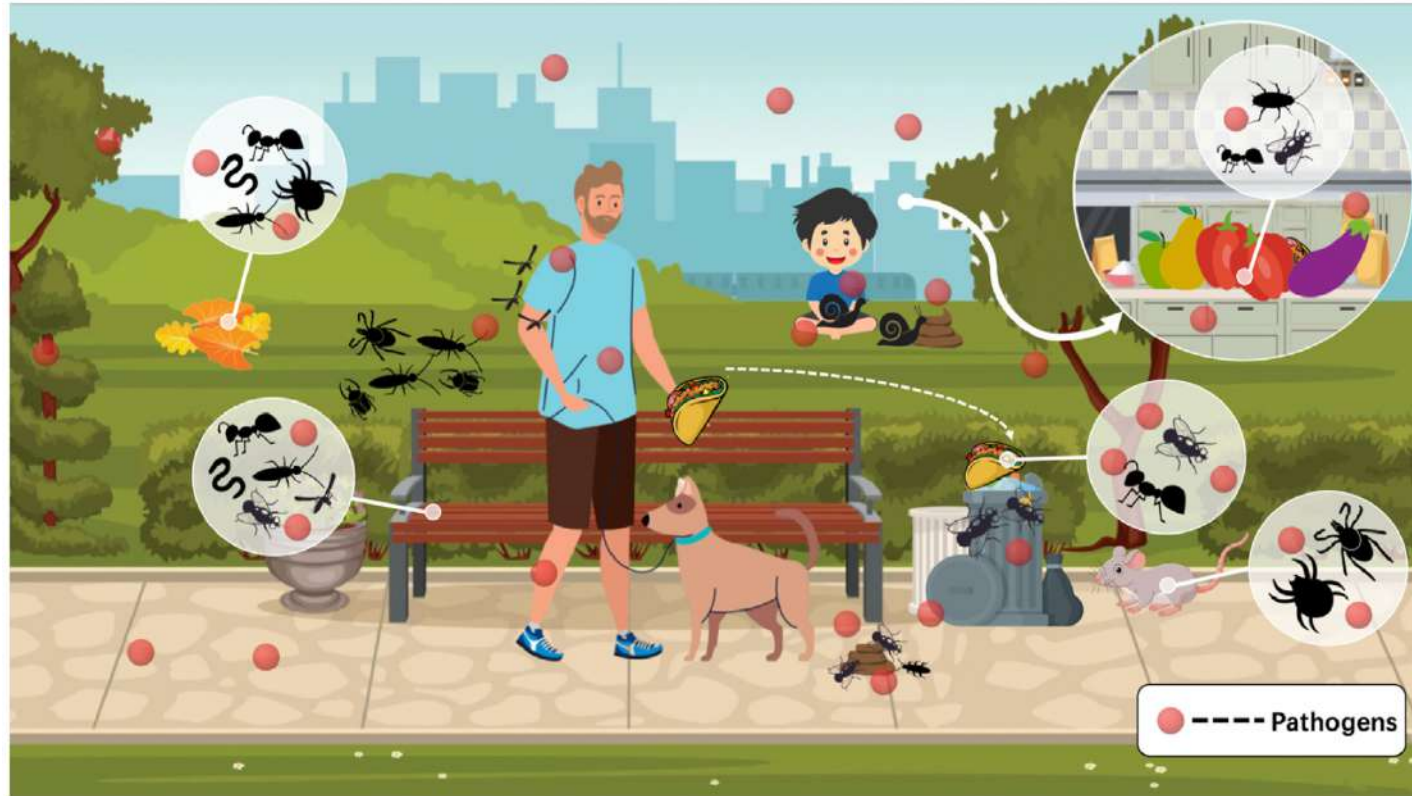
Anton M. Potapov



Terrestrial invertebrate hosts of human pathogens in urban ecosystems

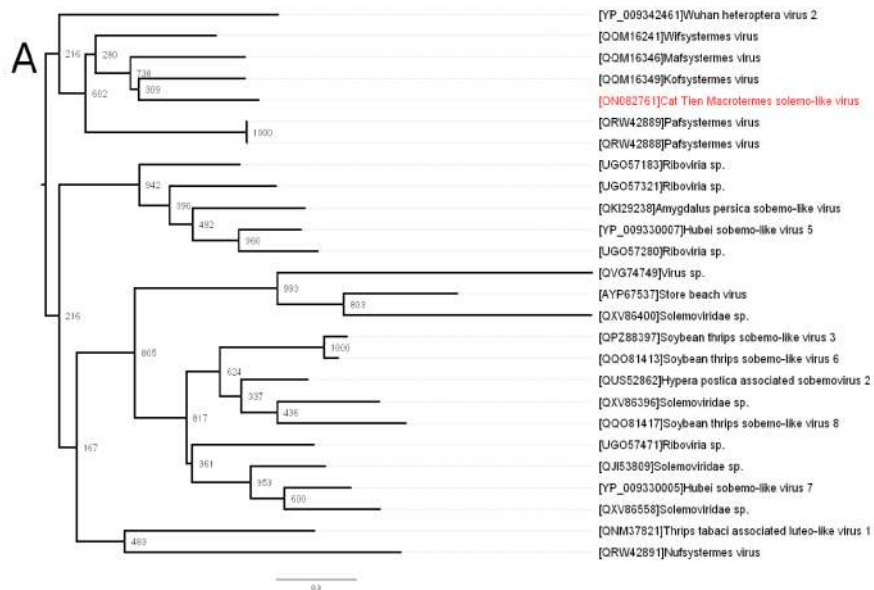
An Xie^{a,b,c,1}, Yiyue Zhang^{a,c,1}, Martin F. Breed^d, Xinli An^{a,c}, Haifeng Yao^{a,b,c},
Qiansheng Huang^{a,b,c,*}, Jianqiang Su^{a,b,c}, Xin Sun^{a,b,c,*}

Анастасия Касаткина
Анастасия Короткевич



Virome of Three Termite Species from Southern Vietnam

Alexander G. Litov ¹, Anna I. Zueva ², Alexei V. Tiunov ², Nguyen Van Thinh ³, Natalia V. Belyaeva ⁴ and Galina G. Karganova ^{1,5,6,*}

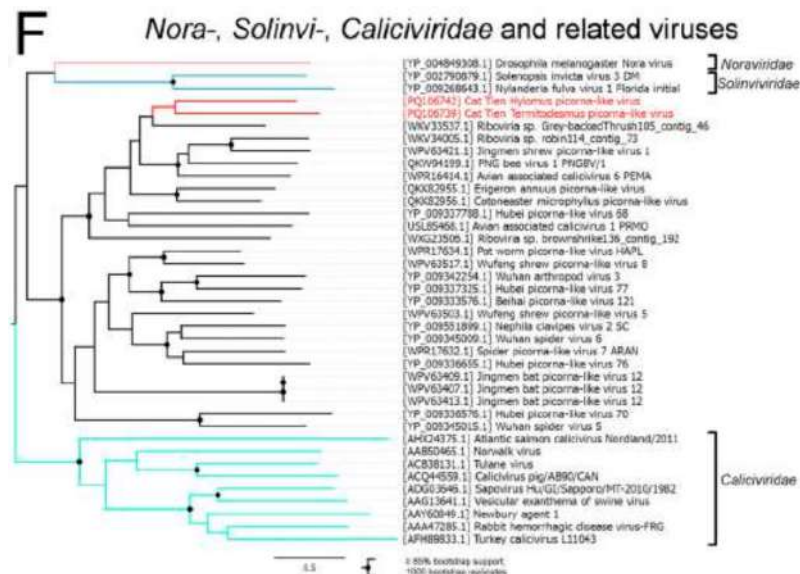


B Cat Tien Macrotermes solemo-like virus



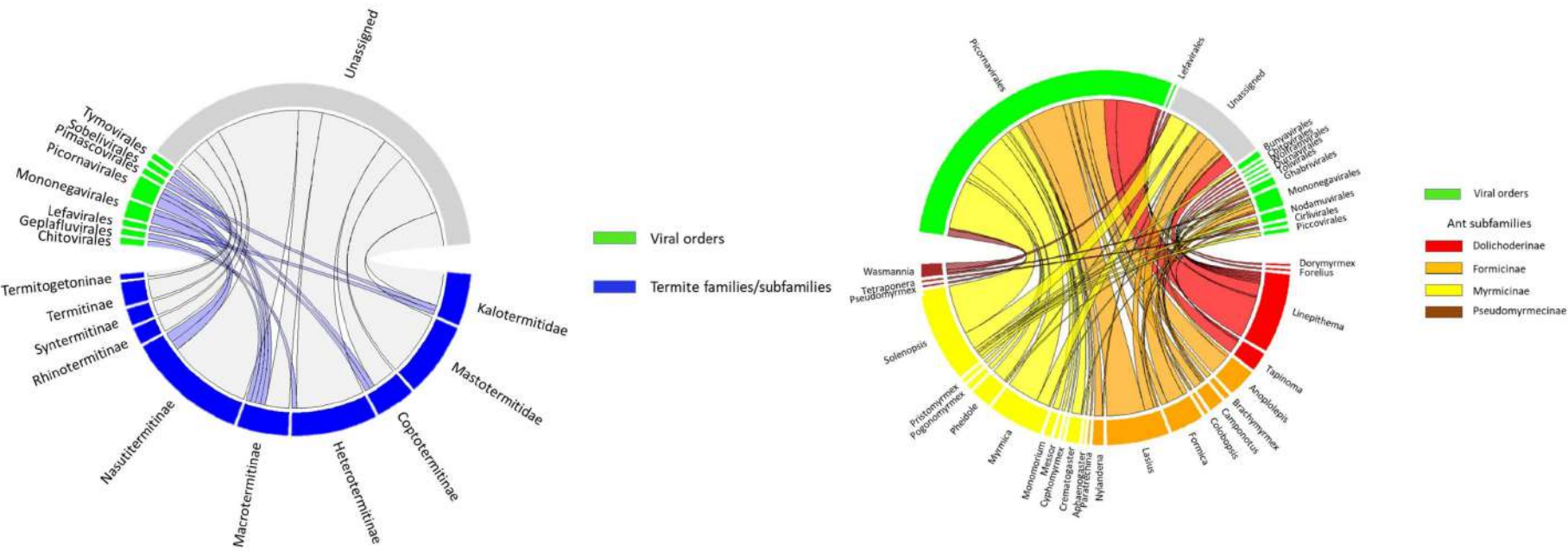
Extensive Diversity of Viruses in Millipedes Collected in the Dong Nai Biosphere Reserve (Vietnam)

Alexander G. Litov ^{1,2,*}, Irina I. Semenyuk ^{3,4}, Oxana A. Belova ¹, Alexandra E. Polienko ¹, Nguyen Van Thinh ⁴ Galina G. Karganova ^{1,2,†} and Alexei V. Tiunov ^{3,†}



Viruses of ants and termites: a review

A. I. Zueva^{1,2} · A. G. Zuev^{1,2} · A. G. Litov^{3,4} · G. G. Karganova^{3,4} · A. V. Tiunov¹

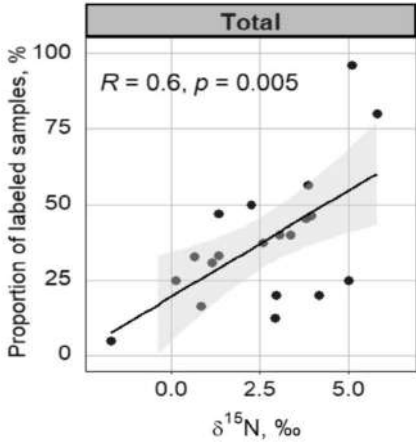
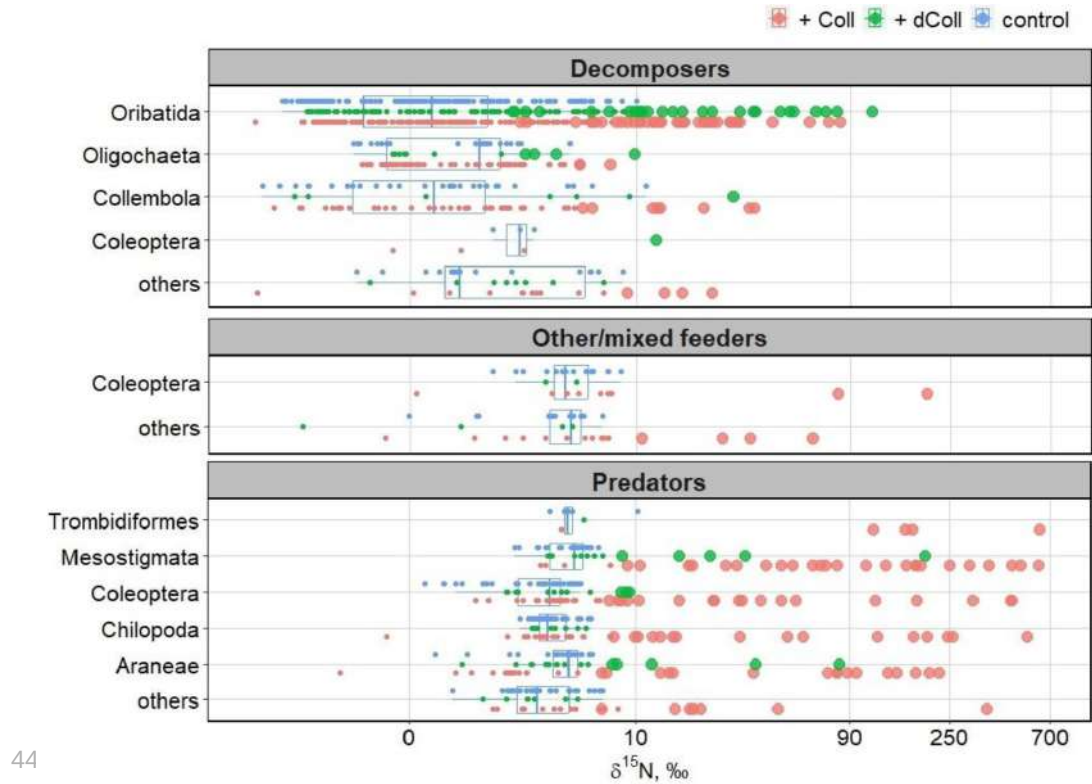


Новые вопросы: «вертикальные связи»

Incorporation of the ¹⁵N-labeled simulated arthropod rain in the soil food web

Oksana L. Rozanova¹ · Sergey M. Tsurikov¹ · Alexey A. Kudrin² · Vladislav D. Leonov¹ · Marina G. Krivosheina¹ · Dmitry N. Fedorenko¹ · Andrei V. Tanasevitch¹ · Leonid B. Rybalov¹ · Alexei V. Tiunov¹

Оксана
Розанова

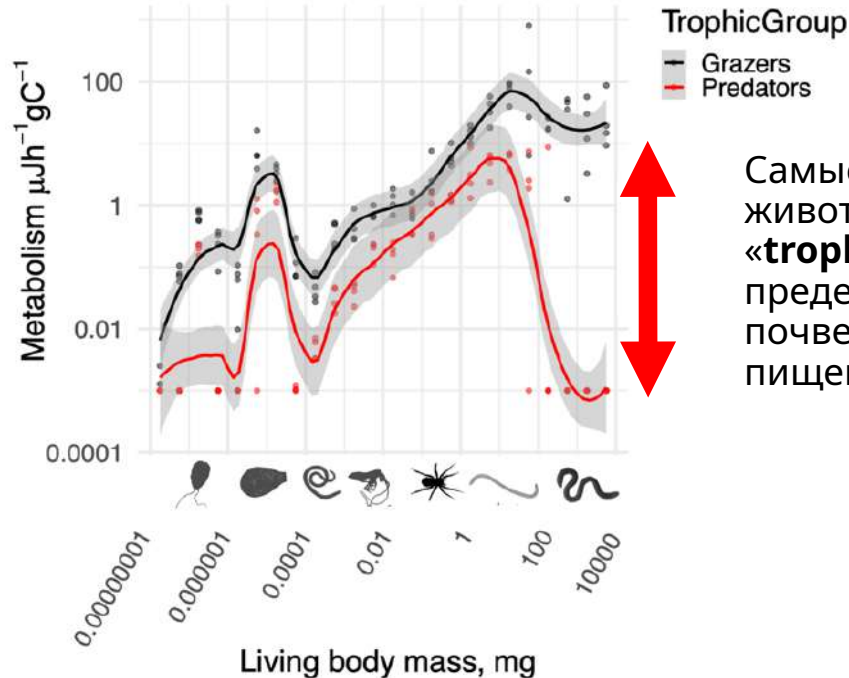


Роль **артроподного дождя** уникальна среди всех «надземных поступлений», поскольку поддерживает преимущественно почвенных хищников

Size compartmentalization of energy channeling in terrestrial belowground food webs

ANTON M. POTAPOV^{1,2,8}, OKSANA L. ROZANOVA,¹ EUGENIA E. SEMENINA,¹ VLADISLAV D. LEONOV,¹
OLGA I. BELYAKOVA,³ VARVARA YU. BOGATYREVA,¹ MAXIM I. DEGTYAREV,^{1,4} ANTON S. ESAULOV,³
ANASTASIYA YU. KOROTKEVICH,⁵ ALEXEY A. KUDRIN,⁶ ELENA A. MALYSHEVA,³ YURI A. MAZEI,^{1,4,7}
SERGEY M. TSURIKOV,¹ ANDREY G. ZUEV,¹ AND ALEXEI V. TIUNOV¹

Потоки энергии через
разные размерные
компарменты пищевой
сети



Подземная энергия рвется из почвы



В разных формах

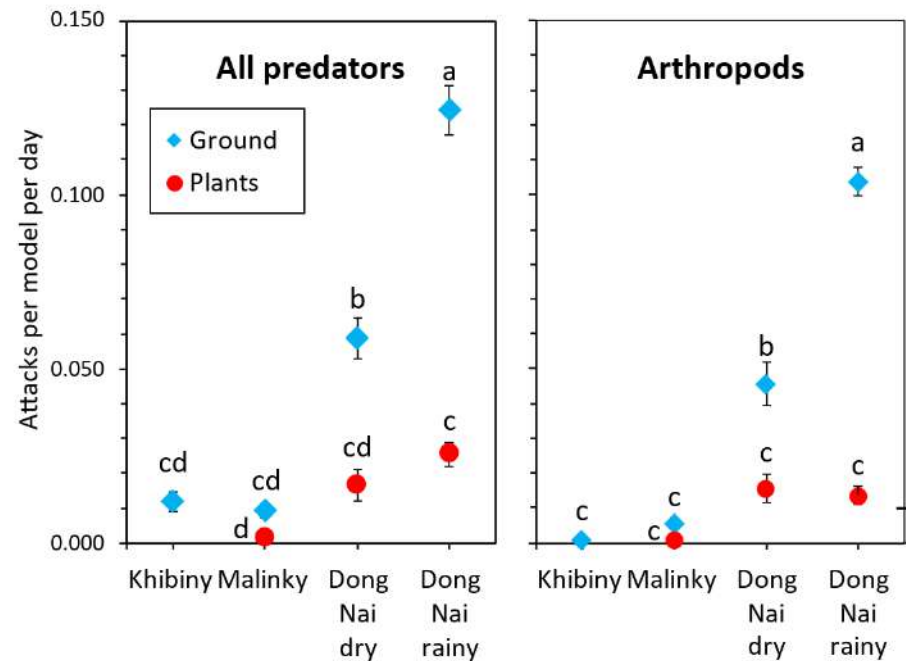


И кормит неизвестно (пока) какую долю наземных животных



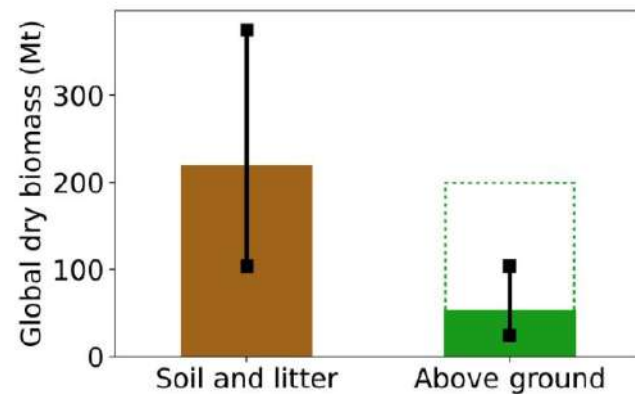
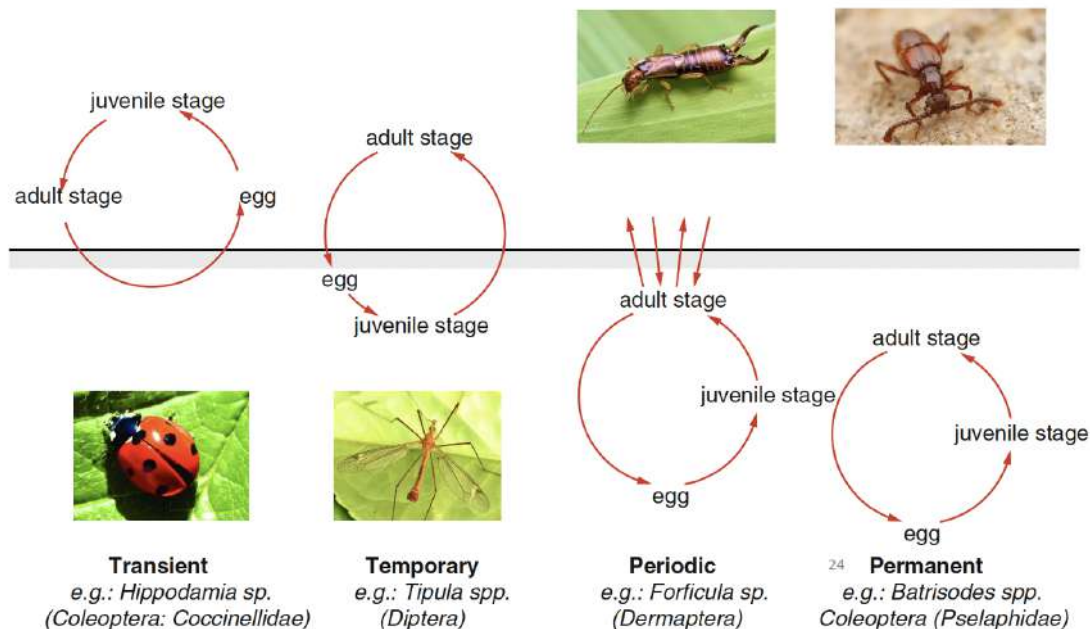
Plasticine models confirm high predator pressure on surfaced earthworms in different ecosystems

Dmitry D. Vinogradov*, Ivan V. Sotnikov, Alexei V. Tiunov



2208 пластилиновых червей и 1668 пластилиновых гусениц

Насекомые (и даже мелкие) – видимо один их главных агентов связи подземного и наземного миров



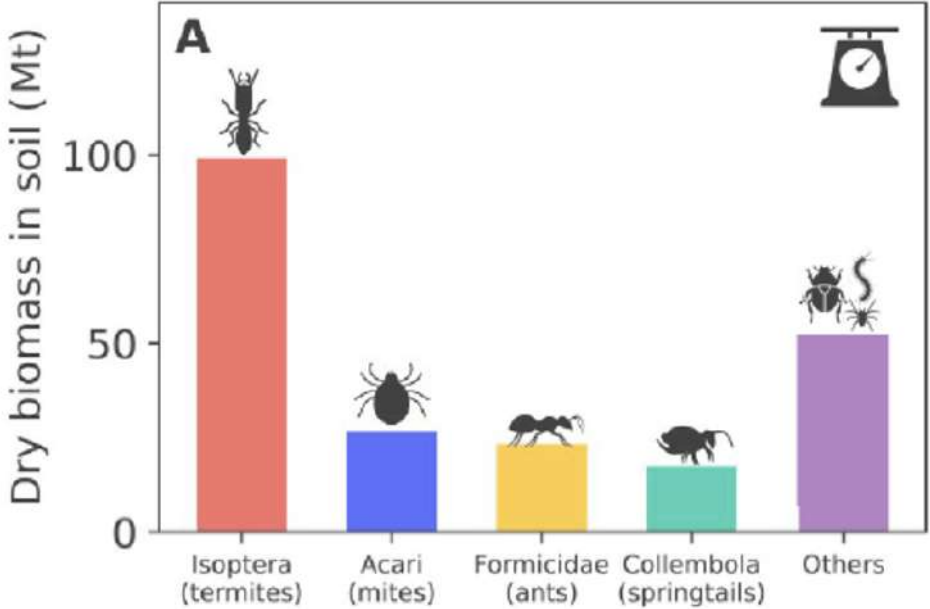
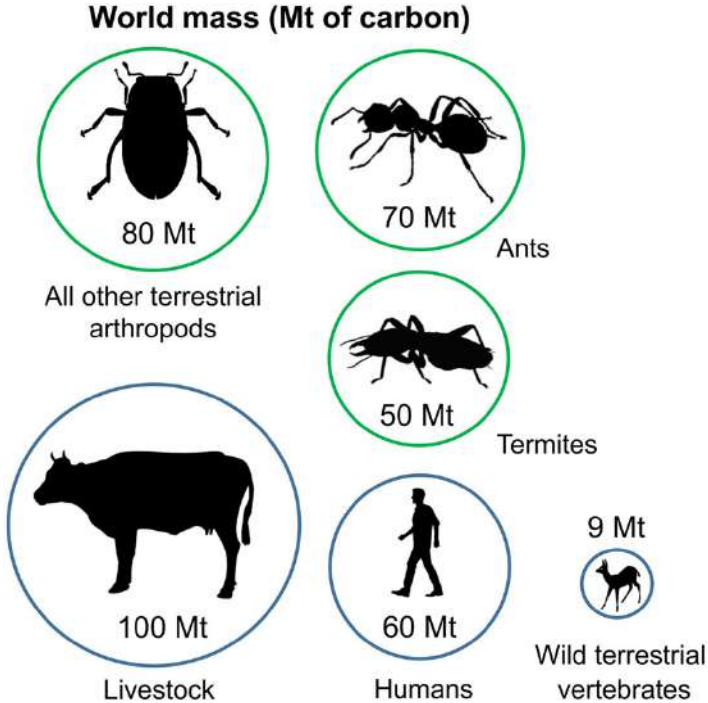
Blume et al. (2016), Coleman & Crossley (1995), Wallwork (1970), ...

Global terrestrial biomass of
arthropods
Rosenberg et al. 2023

А социальные насекомые способны поддерживать крупных специализированных позвоночных хищников.
(В основном в тропиках, но неизвестно, проживут ли без муравьев медведи).



Общественных насекомых в почве очень много – порядка 120 Мт углерода, т.е. больше, чем всех остальных наземных артропод, вместе взятых



Tuma et al. 2020

Rosenberg et al. 2023

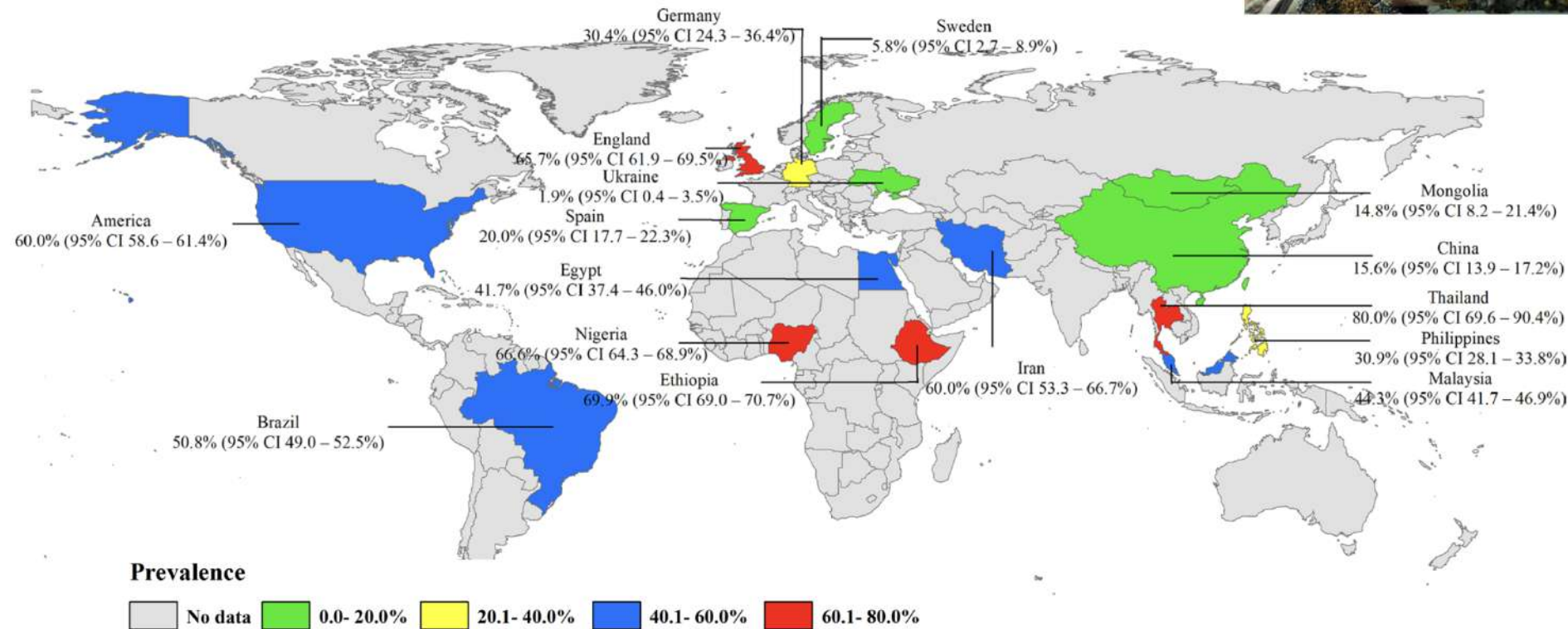
Эмергентные ловушки

Дмитрий Виноградов



The global prevalence of parasites in non-biting flies as vectors: a systematic review and meta-analysis

Yufeng Liu^{1,2,3}, Yuancai Chen^{1,2,3}, Nanhao Wang^{1,2,3}, Huikai Qin^{1,2,3}, Longxian Zhang^{1,2,3} and Sumei Zhang^{1,2,3*}



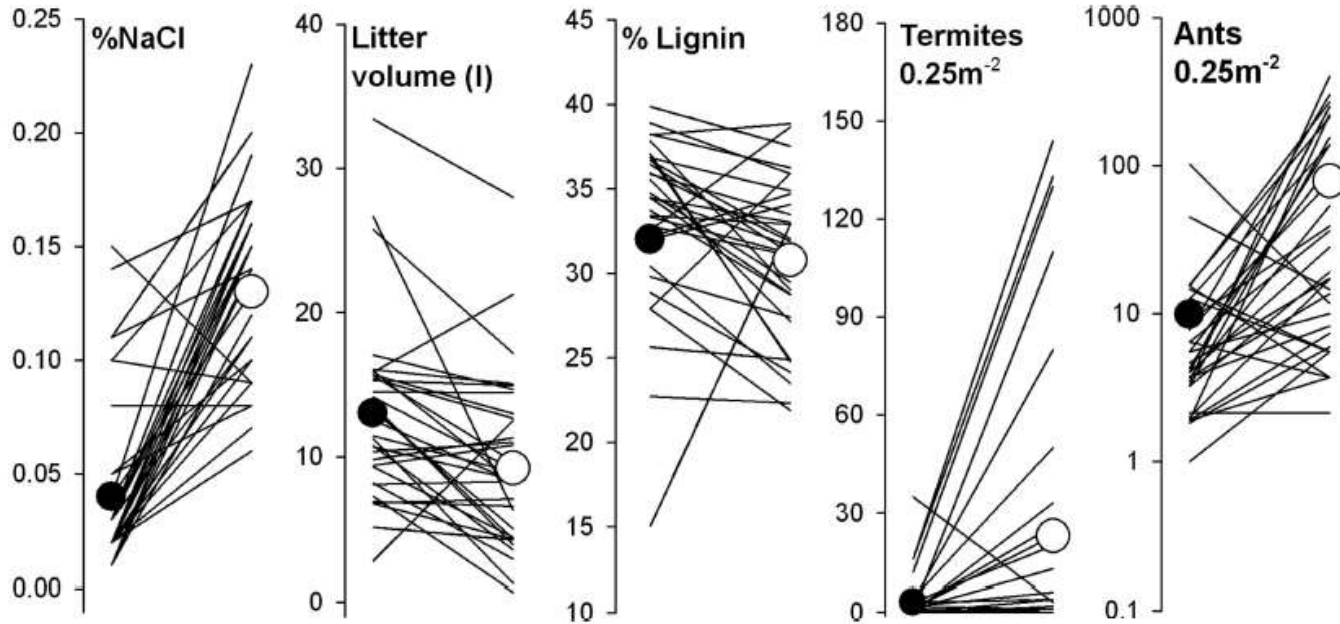
Новые-старые вопросы: стехиометрия



Андрей Дмитриевич Покаржевский

Sodium shortage as a constraint on the carbon cycle in an inland tropical rainforest

Michael Kaspari^{a,b,1}, Stephen P. Yanovlak^c, Robert Dudley^d, May Yuan^a, and Natalie A. Clay^a



Advances in Agronomy 2025; 189: 1-
Zinc in soil-crop-animal-human health continuum

Nanthi Bolan, Ch. Srinivasarao, Claudia Rocco et al.

*Во всем мире более половины сельскохозяйственных почв характеризуются естественным дефицитом Zn, а здоровье примерно трети населения Земли страдает от дефицита Zn. **В развивающихся странах дефицит Zn рассматривается как пятая по значимости причина заболеваний и смертности людей.***

Discover Soil (2025) 2:89

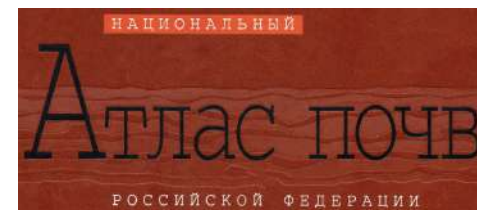
Molybdenum in soil-plant system: bioavailability, dynamics and implications for sustainable crop production

Mannat Rana¹, Narender K. Sankhyani¹, Praveen Thakur¹, Bhawna Babal^{1,2}, Anjali¹, Shweta Sharma¹, Shilpa Kumari¹ and Pardeep Kumar^{1*}

Дефицит молибдена (Mo) — одна из наиболее распространённых проблем микроэлементного питания растений. Дефицит Mo негативно влияет на здоровье человека, тогда как его избыток вызывает токсичность у растений и молибденоз у сельскохозяйственных животных.

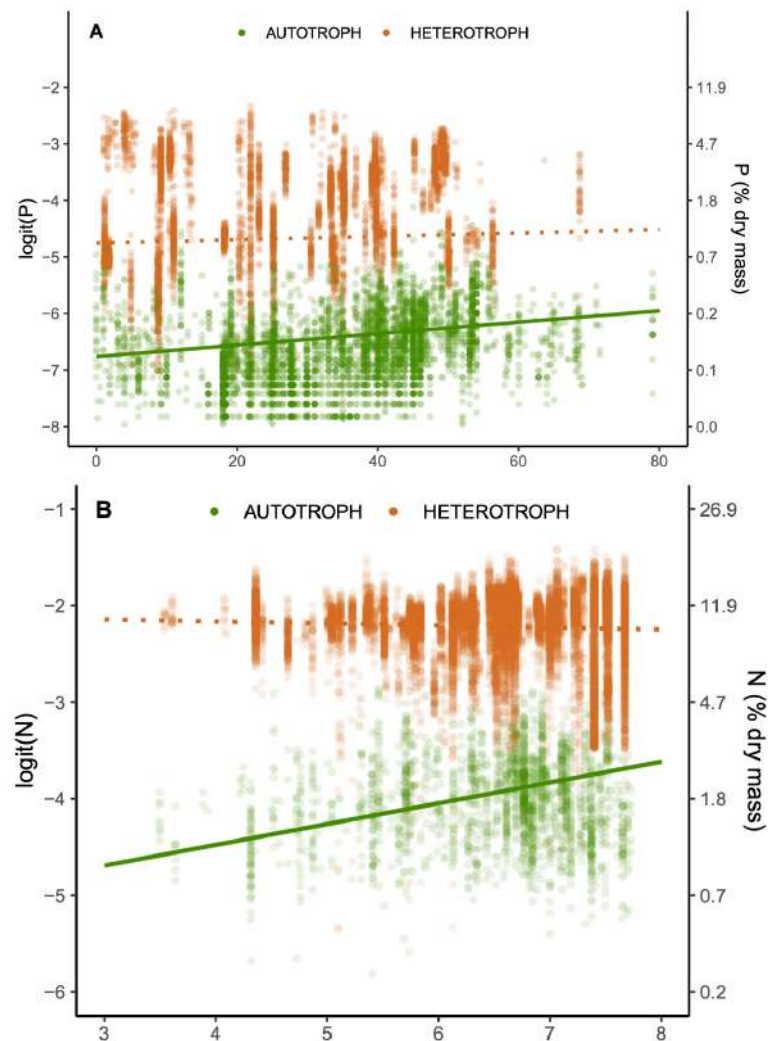
*Илья Любечанский?
Елена Бельская?*

Содержание цинка в почве



Nitrogen deposition reveals global patterns in plant and animal stoichiometry

Angélica L. González ^{1,2,45} , Julian Merder ³, Karl Andraczek ^{4,5}, Ulrich Brose ^{4,6}, Michał Filipiak ⁷, W. Stanley Harpole ^{4,8,9}, Helmut Hillebrand ^{10,11,12}, Michelle C. Jackson ¹³, Malte Jochum ^{4,14,15}, Shawn J. Leroux ¹⁶, Mark P. Nessel ^{2,17}, Renske E. Onstein ^{4,18}, Rachel Paseka ¹⁹, George L. W. Perry ²⁰, Angie Peace²¹, Amanda Rugenski²², Judith Sitters ^{23,24}, Erik Sperfeld^{25,26}, Maren Striebel¹⁰, Eugenia Zandona ²⁷, Attila Mozsár ²⁸, Sarah Bluhm ²⁹, Hideyuki Doi ³⁰, Nico Eisenhauer ^{4,15}, Vinicius F. Farjalla ³¹, James Hood ^{32,33}, Pavel Kratina ³⁴, Catherine Lovelock ³⁵, Eric K. Moody³⁶, Melanie E. Pollierer ²⁹, Anton Potapov^{4,15,29}, Gustavo Q. Romero³⁷, Jean-Marc Roussel ³⁸, Stefan Scheu ^{29,39}, Nicole Scheunemann^{29,40}, Julia Seeber ^{41,42}, Michael Steinwandter ⁴¹, Winda Ika Susanti²⁹, Alexei Tiunov ^{43,44} & Olivier Dézerald ^{38,45} 



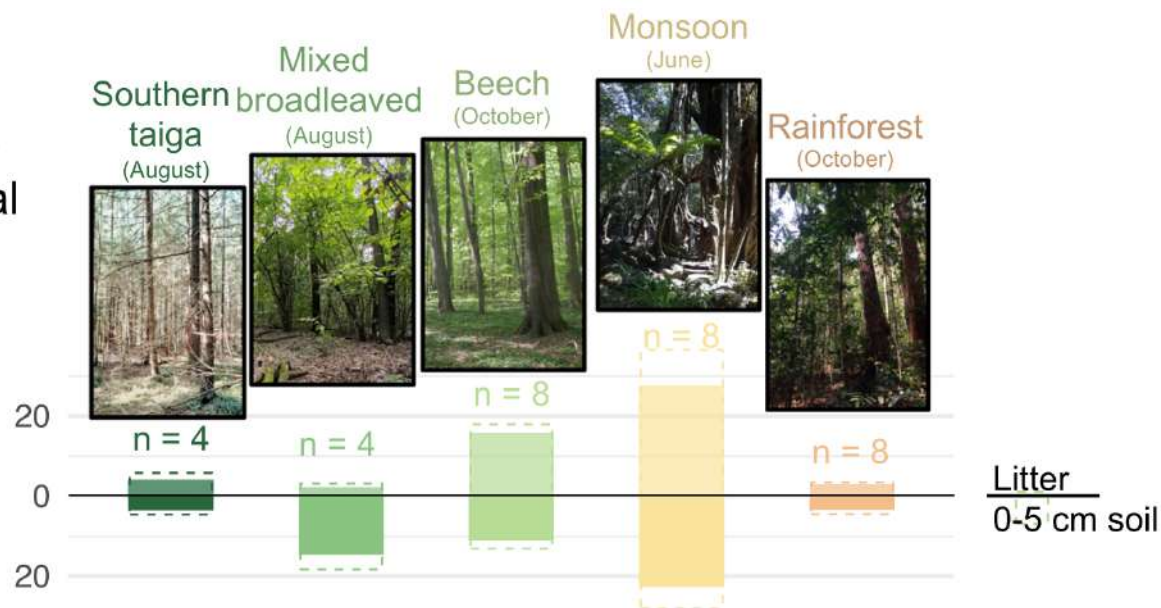
Energy and biomass distribution in soil food webs of temperate and tropical forests

Сергей Цыриков

Anton M. Potapov ^{1,2,3,4} ✉, Irina Semenyuk ^{5,6}, Sarah L. Bluhm ¹,
Valentyna Krashevskaya ^{1,7}, Alexey Kudrin ⁸, Varvara Migunova ⁵,
Melanie M. Pollierer ^{1,9}, Oksana Rozanova ⁵, Sergey M. Tsurikov ⁵,
Zheng Zhou ¹, Andrey G. Zuev ^{2,5}, Anna I. Zueva ^{2,5}, Stefan Scheu ^{1,10},
Alexei V. Tiunov ^{5,11}

Temperate
and tropical
forests

Fresh
biomass
[g m⁻²]



Чего нам не хватает

Soil nematode abundance and functional group composition at a global scale

Johan van den Hoogen^{1,57*}, Stefan Geisen^{1,2,57}, Devin Routh¹, Howard Ferris¹, Walter Trautspurger¹, David A. Wardle⁵, Ron G. M. de Goede⁶, Byron J. Adams⁷, Wasim Ahmad⁸, Walter S. Andriuzzi⁹, Richard D. Bardgett¹⁰, Michael Bonkowski¹¹, Raquel Campos-Herrera¹², Juvenil E. Cares¹³, Tancredi Caruso¹⁴, Larissa de Brito Caixeta¹³, Xiaoyun Chen¹⁵, Sofia R. Costa¹⁶, Rachel Creamer¹⁷, José Mauro da Cunha Castro¹⁷, Marie Dam¹⁸, Djibril Djigal¹⁹, Miguel Escuer²⁰, Bryan S. Griffiths²¹, Carmen Gutiérrez²⁰, Karin Hohberg²², Daria Kalinkina²³, Paul Kardol²⁴, Alan Kergunteuil²⁵, Gerard Korthals², Valentyna Krashevskaya²⁶, Alexey A. Kudrin²⁷, Qi Li²⁸, Wenju Liang²⁸, Matthew Magilton¹⁴, Mariette Marais²⁹, José Antonio Rodríguez Martín³⁰, Elizaveta Matveeva²³, El Hassan Mayad³¹, Christian Mulder³², Peter Mullin³³, Roy Neilson³⁴, T. A. Duong Nguyen^{11,35}, Uffe N. Nielsen³⁶, Hiroaki Okada³⁷, Juan Emilio Palomares Rius³⁸, Kaiwen Pan³⁹, Vlada Peneva⁴⁰, Loïc Pellissier^{41,42}, Julio Carlos Pereira da Silva⁴³, Camille Pitteloud⁴¹, Thomas O. Powers³³, Kirsten Powers³³, Casper W. Quist^{44,45}, Sergio Rasmann⁴⁶, Sara Sánchez Moreno⁴⁷, Stefan Scheu^{26,48}, Heikki Setälä⁴⁹, Anna Sushchuk²³, Alexei V. Tunov⁵⁰, Jean Trap⁵¹, Wim van der Putten^{2,45}, Mette Vestergård⁵², Cecile Villenave^{51,53}, Lieven Waeyenbergh⁵⁴, Diana H. Wall⁹, Rutger Wilschut¹², Daniel G. Wright⁵⁵, Jiue-In Yang⁵⁶ & Thomas Ward Crowther^{1*}

Article

<https://doi.org/10.1038/s41467-023-36216-6>

Globally invariant metabolism but density-diversity mismatch in springtails

Anton M. Potapov^{1,2,3,4}, Carlos A. Guerra^{3,4}, Johan van den Hoogen⁵, Anatoly Babenko⁶, Bruno C. Bellini⁶, Matty P. Berg^{7,8}, Steven L. Chown⁹, Louis Deharveng¹⁰, Lubomír Kováč¹¹, Natalia A. Kuznetsova¹², Jean-François Ponge¹³, Mikhail B. Potapov¹², David J. Russell¹⁴, Douglas Alexandre¹⁵, Juha M. Alatalo¹⁶, Javier I. Arbea¹⁷, Ipsa Bandyopadhyaya¹⁸, Verónica Bernava¹⁹, Stef Bokhorst²⁰, Thomas Bolger^{20,21}, Gabriela Castaño-Meneses²², Matthieu Chauvat²³, Ting-Wen Chen^{24,1}, Mathilde Chomel²⁵, Aimee T. Classen²⁶, Jerome Cortez²⁷, Peter Čuchta²⁴, Ana Manuela de la Pedrosa²⁸, Susana S. D. Ferreira²⁹, Cristiana Fiera²⁹, Juliane Filser³⁰, Oscar Franken³¹, Saori Fujii³², Essivi Gagnon Koudji³³, Meixiang Gao³⁴, Benoit Gendreau-Berthiaume³⁵, Diego F. Gomez-Pamies³⁶, Michelle Greve³⁷, I. Tanya Handa³⁸, Charlene Heiniger³⁸, Martin Holmström³⁹, Pablo Homet⁴⁰, Mari Ivask⁴¹, Charlene Janion-Schepers^{42,43}, Malte Jochum^{3,4}, Sophie Joimel⁴⁴, Bruna Claudia S. Jorge⁴⁵, Edite Jucevica⁴⁶, Olga Ferlian^{3,4}, Luis Carlos Luñes de Oliveira Filho⁴⁷, Osmar Klausberg-Filho⁴⁷, Dilar Barretta⁴⁸, Eveline J. Krab^{49,50}, Annelly Kuu⁵¹, Estevam C. A. de Lima⁵², Dunnei Lin⁵³, Zoe Lindo⁵⁴, Amy Liu⁵, Jing-Zhong Lu¹, Maria José Lucíañez²⁸, Michael T. Marx⁵⁵, Matthew A. McCary⁵⁶, Maria A. Minor⁵⁷, Taizo Nakamori⁵⁸, Ilaria Negri⁵⁹, Raúl Ochao-Hueso^{60,61}, José G. Palacios-Vargas⁶², Melanie M. Pollier⁶³, Pascal Querner^{63,64}, Natália Raschmanova⁶¹, Muhammad Imtiaz Rashid⁶⁵, Laura J. Raymond-Léonard³³, Laurent Rousseau³³, Ruslan A. Saifutdinov⁶², Sandrine Salmon⁶⁶, Emma J. Sayer^{67,68}, Nicole Scheunemann^{1,69}, Cornelia Scholz⁶⁴, Julia Seeber^{70,71}, Yulia B. Shveenkov⁷², Sophia K. Stebaeva², Maria Sterzynska⁷³, Xin Sun⁷⁴, Winda I. Susanti¹, Anastasia A. Taskaeva⁷⁵, Madhav P. Thakur⁷⁶, Maria A. Tsiafoulis⁷⁷, Matthew S. Turnbull⁷⁸, Mthokozisi N. Twala⁷⁹, Alexei V. Uvarov², Lisa A. Venier⁷⁹, Lina A. Widenfalk^{80,81}, Bruna R. Winck⁴⁵, Daniel Winkler⁸², Donghui Wu^{83,84,85}, Zhijiang Xie⁸³, Rui Yin⁸⁶, Douglas Zeppelini⁸⁷, Thomas W. Crowther⁹, Nico Eisenhauer^{3,4} & Stefan Scheu^{1,88}

BIOGEOGRAPHY

Global distribution of earthworm diversity

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RESEARCH ARTICLE

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Soil health assessment using buried cotton underpants with the help of 1000 citizen scientists

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Soil health assessment using buried cotton underpants with the help of 1000 citizen scientists

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