Ratios Matter

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Welcome to Ratios Matter!

This is the inaugural issue of Ratios Matter, a newsletter all about ecological stoichiometry and elemental ratios. Here you will find stoichiometric news including announcements of upcoming events and summaries of recent publications. Anything might show up in the pages of Ratios Matter that is of interest to the stoichiometrist at large. **Send us your suggestions for future issues. Or, better yet, your own stoichiometric contributions– ideas, perspectives, comments, photos and ramblings– all are welcome.** To receive each issue automatically, subscribe for free by sending us an email (ratiosmatter@gmail.com). Look for a new issue of Ratios Matter about every 3 months.

Inside this issue:

John H. Martin Award

Congratulations to Dag Hessen and Bob Sterner for receiving the 2017 John H. Martin Award for their 1994 paper "Algal nutrient limitation and the nutrition of aquatic animals". This award is given by the Association for the Sciences of Limnology and Oceanography to a paper in aquatic sciences that is judged to have had a high impact on subsequent research in the field. With over 400 citations and counting and for its importance in generating interest in ecological stoichiometry, this is a well-deserved award.

From the paper, "*For example, should the RNA hypothesis discussed here hold up to further scrutiny, it will be possible to see a clear thread extending all the way from molecular biology to ecosystem function*". Very prescient.

Editorial Board

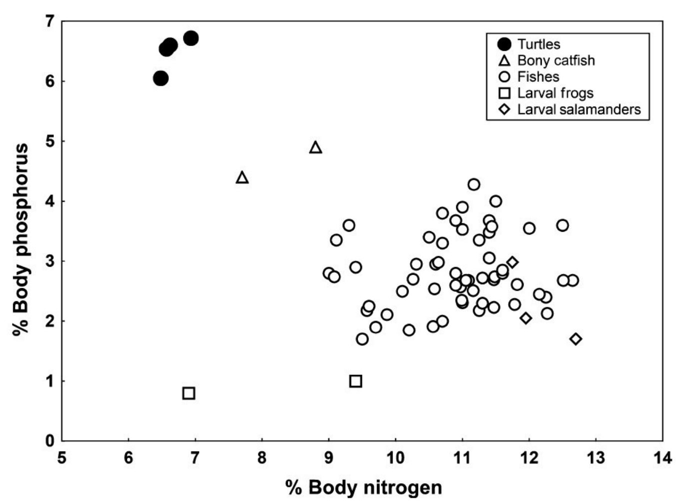
Special Session

Abstracts are being accepted for a special session, **Elements and energy as fundamental currencies of nature: using ecological stoichiometry as a tool to advance the sustainability of freshwater ecosystems,** planned for the Society for Freshwater Science meeting in Raleigh, North Carolina on June 4-9th 2017. The goal of this session is to synthesize and identify opportunities to improve the sustainability of freshwater ecosystems using ecological stoichiometry. Abstract submission is open until Feb 23rd, 2017. Meeting details can be found here:

http://sfsannualmeeting.org/

In Case You Missed It

Turtle stoichiometry! With 82% of dry mass found in their skeletons and bone P content of 8.5% by dry mass, turtles have an especially low body N:P ratio. Even lower than bony catfish! For the full story, see: Sterrett, Sean C., John C. Maerz, and Rachel A. Katz. "What can turtles teach us about the theory of ecological stoichiometry?" Freshwater Biology 60.3 (2015): 443-455. This paper was a contribution to a special issue in Freshwater Biology on ecosystem effects of consumer-driven nutrient cycling (**http://onlinelibrary.wiley.com/doi/10.1111/fwb.2015.60.issue-3/issuetoc**).



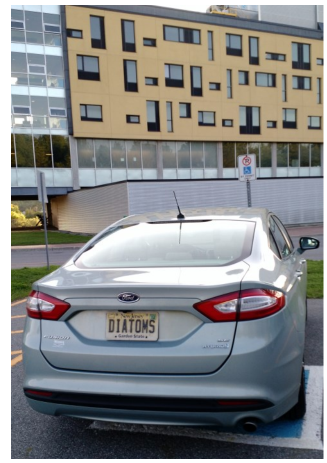
Body P and N content of turtles relative to other aquatic vertebrates. Figure from Sterrett et al. (2015) Freshwater Biology. Reprinted with permission of John Wiley and Sons, Inc.

Out of Africa and Into Stoichiometry

If you work on ecological stoichiometry, there is a good chance that you have been influenced in one way or another by the "godmother" of stoichiometry, Sue Kilham. In this paper, Sue provides a firsthand account of the development of resource ratio theory and its use in linking microbial ecology and biochemistry. This piece is an inspiring and illuminating look back into the genesis of our field, which follows Sue and her husband, Peter, through the early development and application of resource ratio theory.

The story begins with Peter's work in Africa studying water chemistry and its effects on diatom assemblages. This work directly prompted the well-known studies of the effects of Si- and P-limitation on diatoms by Sue and David Tilman, which led to the development of R* theory. Next, we get a tour of diverse limnological discoveries of the Kilhams' including the development of one of the most important inventions in the past 20 years: COMBO media! The paper ends with a look back at Sue's work with Sebastian Interlandi and their elegant studies of spatiotemporal variation in light and nutrient stoichiometry (N, P, and Si) in Yellowstone National Park. They assessed the role of multi-resource limitation in shaping phytoplankton species diversity.

In all, Sue's article serves as an inspiration to think and collaborate broadly. Altogether, her body of work demonstrates the power of ratios for answering important ecological questions through the generation of unexpected and deep insights into the connections between nutrients, physiology, and ecological interactions.



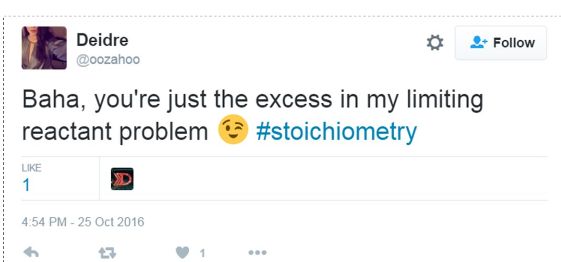
From the paper

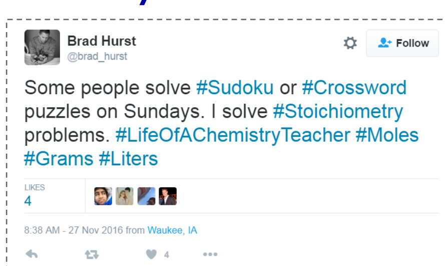
"Collaborations go well largely because of separate though compatible perspectives. Wonderful mentors, colleagues, and graduate students inspire with their new perspectives." Thanks to Sue for inspiring us all.

Contributed by Clay Prater

Kilham, S.S.,and P. Kilham. 2016. "Out of Africa and into Stoichiometry." In *Aquatic Microbial Ecology and Biogeochemistry: A Dual Perspective.* Springer International Publishing. Pg. 67-75.

From the Twitter world: #stoichiometry





Stoichiometry of *Synechococcus*

Dynamic C:N:P ratios in a globally ubiquitous autotroph

Cyanobacteria are abundant throughout the ocean and contribute substantially to primary production, yet their stoichiometric physiology has received less attention than other phytoplankton. A recent paper by Nathan Garcia, Juan Bonachela and Adam Martiny (ISMEJ 2016) systematically examined the stoichiometry of the marine cyanobacterium, *Synechococcus.* They found that biomass C:P and N:P decline with growth rate when P-limited, but biomass stoichiometry was comparably less variable under N-limitation. While this pattern is consistent with other studies in phytoplankton and the predictions of models, their paper suggests there are different underlying mechanisms than previously thought. As in the Droop model, the quotas of N and P increased with growth rate in *Synechococcus.* But, cell size and C quota also increased with growth rate, which is not predicted in the Droop model. When the effect of cell size was included in their modified model, they showed how increasing growth rate might lead to increased quotas of non-limiting elements. Relatedly, the growth rate hypothesis predicts that biomass P content increases with P-limited growth rate due to the demand for P-rich ribosomal RNA. Although the P-quota of *Synechococcus* increased with growth rate (by more than 100%), this was not attributable to an increase in RNA or DNA.

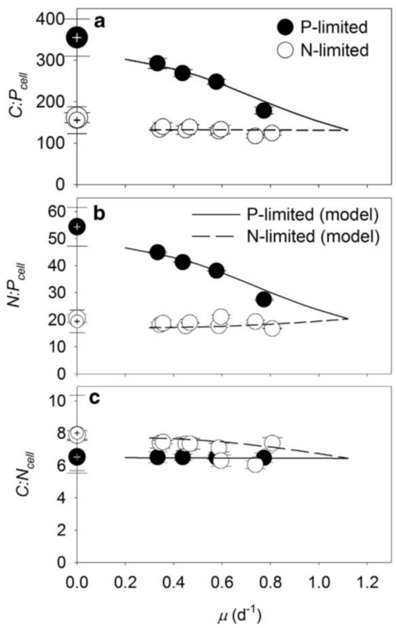


Figure 4 from Garcia et al. (2016) ISME J. Reprinted with permission of Nature Publishing Group, Inc.

From the paper *"Our findings further suggest that fundamentally different biochemical mechanisms may control the cellular elemental stoichiometry of small vs large phytoplankton, such as Cyanobacteria vs eukaryotes."*

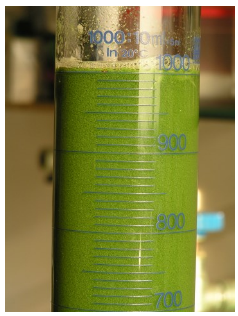
One key implication of this work is that modeling the biomass chemistry of this ubiquitous group requires more than selecting a characteristic C:N:P ratio. At a minimum, it requires knowledge of which nutrient is most limiting and the relative growth rate of the cells in their environment. While that may be a tall order, this group has made remarkable progress toward linking stoichiometric physiology with large-scale biogeochemistry (also see Galbraith and Martiny 2015, PNAS; Martiny et al 2016 PLos One).

Contributed by Casey Godwin

Garcia, N.S., Bonachela, J.A., and Martiny, A.C. (2016). Interactions between Growth-Dependent Changes in Cell Size, Nutrient Supply and Cellular Elemental Stoichiometry of Marine Synechococcus. ISME J 10: 2715-2724 (doi:10.1038/ismej.2016.50.)

2016 ISSHA Patrick Gentien Young Scientist Award

Congratulations to Dedmer Van de Waal, who received the International Society for the Study of Harmful Algae (ISSHA) 2016 Patrick Gentien Young Scientist Award for his work on the coupling of stoichiometrically distinct cyanobacterial and algal toxins to the elemental composition of its producer, and thus linking toxin production to the general framework of ecological stoichiometry.



ISSHA was founded in response to a request by the Intergovernmental Oceanographic Commission (IOC) of UNESCO for an international programme on harmful algae. ISSHA promotes and fosters research and training on harmful algae, and co-sponsors the International Conference on Harmful Algae. ISSHA offers the Patrick Gentien Young Scientist Award every two years during these conferences in recognition of outstanding achievement in any aspect of harmful algal research by a scientist early in their career.

http://www.issha.org/Welcome-to-ISSHA/Awards/Achievement-Awards/2016-ISSHA-Awardees

Help add an **element of surprise** to an upcoming issue of Ratios

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Ah!

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Matter by sending in your stoichiometric news, photo, or contribution. Email us at **ratiosmatter@gmail.com**

ASLO 2017 Mountains to the Sea

Headed to Hawaii for the Aquatic Sciences meeting? Stoichiometry sure will be. At least 21 talks and posters have stoichiometry in their title and/or abstract. Here is a selection of what's on the menu. Check out the **ASLO 2017 Program** for full details (web address below).

Faithfull, C.L.; Mathews, L.; Nelson, C.; How does food quality affect ontogenetic niche shirts in copepods?(Abstract ID: 28507)

Herstoff, E.M.; Boersma, M.; Meunier, C.L.; Baines, S.B.; Does prey stoichiometry influence copepod swimming behaviors across its ontogeny? (Abstract ID: 28942)

Moorthi, S.D. et al.; Unifying ecological stoichiometry and metabolic theory to predict interactive effects on trophic interactions in a marine planktonic food web (Abstract ID: 28976)

Moreno, A.R.; Hagstrom, G.I.; Primeau, F.W.; Levin, S.A.; Martiny, A.C.; Marine phytoplankton physiology and stoichiometry in major ocean biomes effect on atmospheric CO_2 (Abstract ID: 29129)

Mathews, L.E.; Faithfull, C.; Nelson, C.; Nutritional & elemental stoichiometry of microzooplankton life stages in a changing climate (Abstract ID: 29132)

Cotner, J.B.; Godwin, C.M.; Whitaker, E.A.; Relativity trumps absolutism: P pools in microbes and their effects on stoichiometry (Abstract ID: 29376)

Follett, C.L.; White, A.E.; Follows, M.J.; Nitrogen fixation measured by stoichiometric fluctuations (Abstract ID: 29681)

https://www.sgmeet.com/aslo/honolulu2017/

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Selected Recent Stoichiometry Publications

Čapek, P., P. Kotas, S. Manzoni, and H. Šantrůčková. 2016. Drivers of phosphorus limitation across soil microbial communities. Funct. Ecol. 30: 1705–1713. doi:10.1111/1365-2435.12650

Danger, M., M.O. Gessner, and F. Bärlocher. 2016. Ecological stoichiometry of aquatic fungi: Current knowledge and perspectives. Fungal Ecol. 19: 100–111. doi:10.1016/j.funeco.2015.09.004

Ellis, N.M., and S.J. Leroux. 2016. Moose directly slow plant regeneration but have limited indirect effects on soil stoichiometry and litter decomposition rates in disturbed maritime boreal forests. Funct. Ecol. In Press. doi:10.1111/1365-2435.12785

Filipiak, M. 2016. Pollen stoichiometry may influence detrital terrestrial and aquatic food webs. Front. Ecol. Evol. 4: 1–8. doi:10.3389/fevo.2016.00138

Godwin, C.M., E.A. Whitaker, and J.B. Cotner. 2016. Growth rate and resource imbalance interactively control biomass stoichiometry and elemental quotas of aquatic bacteria. Ecology In Press. doi:10.1002/ecy.1705

Krist, A.C., A.D. Kay, E. Scherber, and others. 2016. Evidence for extensive but variable nutrient limitation in New Zealand lakes. Evol. Ecol. 30: 973–990. doi:10.1007/s10682-016-9855-2

Larson, J.H., P.C. Frost, J.M. Vallazza, J.C. Nelson, and W.B. Richardson. 2016. Do rivermouths alter nutrient and seston delivery to the nearshore? Freshw. Biol. 61: 1935–1949. doi:10.1111/fwb.12827

Martiny, A.C., L. Ma, C. Mouginot, J.W. Chandler, and E.R. Zinser. 2016. Interactions between thermal acclimation, growth rate, and phylogeny influence Prochlorococcus elemental stoichiometry. PLoS One 11: e0168291. doi:10.1371/journal.pone.0168291

Midgley, M.G., and R.P. Phillips. 2016. Resource stoichiometry and the biogeochemical consequences of nitrogen deposition in a mixed deciduous forest. Ecology 97: 3369–3377. doi:10.1002/ecy.1595

Peace, A., M.D. Poteat, and H. Wang. 2016. Somatic growth dilution of a toxicant in a predator-prey model under stoichiometric constraints. J. Theor. Biol. 407: 198–211. doi:10.1016/j.jtbi.2016.07.036

Thrane, J.E., D.O. Hessen, T. Andersen, and H. Hillebrand. 2016. The impact of irradiance on optimal and cellular nitrogen to phosphorus ratios in phytoplankton. Ecol. Lett. 19: 880–888. doi:10.1111/ele.12623

Tuckett, Q.M., M.T. Kinnison, J.E. Saros, and K.S. Simon. 2016. Population divergence in fish elemental phenotypes associated with trophic phenotypes and lake trophic state. Oecologia 182: 765–778. doi:10.1007/s00442-016-3714-2

Vanni, M.J., and P.B. McIntyre. 2016. Predicting nutrient excretion of aquatic animals with metabolic ecology and ecological stoichiometry: A global synthesis. Ecology 97: 3460–3471. doi:10.1002/ecy.1582

Wilder, S.M., and P.D. Jeyasingh. 2016. Merging elemental and macronutrient approaches for a comprehensive study of energy and nutrient flows. J. Anim. Ecol. 85: 1427–1430. doi:10.1111/1365-2656.12573