100 YEARS Journal of Ecology
British Ecological Society

Journal of Ecology 2015, **103**, 860–861 doi: 10.1111/1365-2745.12417

COMMENTARY

Wave-induced changes in seaweed toughness entail plastic modifications in snail traits maintaining consumption efficacy: Commentary on Molis *et al.* 2015

Michele Guidone*

Armstrong State University, 11935 Abercorn Street, Savannah, GA 31419, USA

Phenotypic plasticity – the capacity of a single genotype to produce multiple phenotypes in response to an organism's environment – is a wide spread phenomenon among marine intertidal organisms (Padilla & Savedo 2013). The marine intertidal is a dynamic habitat, with abiotic features including wave exposure, immersion time, salinity, nutrients and temperature varying among, and often within, sites. These abiotic factors directly influence the organisms that inhabit this area and also play a role in determining the type and strength of community interactions present such as predation, competition and facilitation (Menge & Sutherland 1987). A number of studies have elucidated the direct impact of abiotic and biotic factors on intertidal organisms' phenotypes (Padilla & Savedo 2013). Fewer studies have examined community level responses to phenotypic changes in plastic organisms, and the majority of these have focused on the indirect impacts of predator presence on lower trophic levels through their behavioural modification of intermediate prey species (trait-mediated indirect effects; Dill, Heithaus & Walters 2003; Miner *et al.* 2005). In contrast, Molis *et al.* (2015) explored a relatively understudied species response to phenotypic plasticity: an herbivore's ability to plastically change the morphology of its feeding apparatus to match the structure of its phenotypically plastic algal food source. This cascade of phenotypic plasticity ultimately arises from an abiotic environmental factor, wave exposure, which distinguishes this study from those focused on the biotic factor of predator-mediated indirect effects (Dill, Heithaus & Walters 2003; Miner *et al.* 2005).

Through a series of field and laboratory experiments, Molis *et al.* (2015) demonstrated that wave exposure mediates the phenotypically plastic trait of seaweed tissue toughness in *Fucus vesiculosus*, which subsequently impacts snail radula tooth length and cusp number in *Littorina obtusata*. Field surveys indicated a positive correlation between *F. vesiculosus* tissue toughness and increasing wave exposure. Transplant experiments in which *F. vesiculosus* blades transplanted from low to high wave exposure sites increased in tissue toughness confirmed the plasticity of this trait. Molis *et al.* (2015) also showed that snail preference for tougher or softer blades is dependent on the snail's site of origin, as snails from wave-protected sites possessed radulas with shorter teeth and fewer cusps. As with algal tissue toughness, snail radular features were found to be plastic, with snails from protected sites developing larger radular teeth and more cusps when provided tougher, wave exposed algal tissues as their only food source in the laboratory.

There are two aspects of the Molis *et al.* (2015) study that distinguish it from previous work on phenotypic plasticity. First, as stated above, it focuses on an abiotically mediated cascade of phenotypic changes as opposed to the more frequently studied biotically mediated cascades. Secondly, this study was conducted in the two geographically distant intertidal areas of Nova Scotia and Helgoland. This type of geographic coverage is a rarity among similar studies, and it provides strong evidence that phenotypic plasticity linked to wave exposure is likely a general feature of both *F. vesiculosus* and *L. obtusata*.

The findings of Molis *et al.* (2015) provide a basis for investigating similar abiotically mediated phenotypic plasticity cascades in other species and in response to a broader range of abiotic factors. For instance, there are now several reports of plastic radular features in marine snails in response to variation in their food source(s) (Padilla 1998; Andrade & Solferini 2006; Molis *et al.* 2015), indicating that phenotypically plastic radulas may be a common feature among marine snails. We can also hypothesize that other herbivores that are tightly linked to an intertidal algal food source may respond similarly to abiotically induced plasticity in their algal prey. Given that many algal species are notoriously morphologically plastic (Mathieson, Norton & Neushul 1981), so much so that modern taxonomic assessments must rely heavily on genetic sequencing rather than morphological identifications (e.g. Saunders 2005), it is possible that this type of interaction is a widespread yet overlooked component of the marine intertidal community.

While numerous instances of phenotypic plasticity have been documented in the marine intertidal, many marine systems remain understudied. As highlighted by Padilla & Savedo (2013), the vast majority of marine phenotypic plasticity

*Correspondence author. E-mail: michele.guidone@armstrong.edu

studies, including Molis *et al.* (2015), have been conducted in temperate intertidal zones with benthic organisms. Marine pelagic and subtidal benthic zones remain poorly studied, as do tropical and polar regions (Padilla & Savedo 2013). As these understudied regions are heavily impacted by anthropogenic activities, including habitat destruction, pollution and climate change (Halpern *et al.* 2007; Doney *et al.* 2012), it is vital to gain a better understanding of phenotypic plasticity as it relates to community interactions (Reed, Schindler & Waples 2011).

Data accessibility

This paper does not contain data.

References

Andrade, S.C.S. & Solferini, V.N. (2006) Environmental effects on the radula of *Littoraria flava* (Gastropoda: Littorinidae). *Journal of Molluscan Studies*, **72**, 111–116.

Dill, L.M., Heithaus, M.R. & Walters, C.J. (2003) Behaviorally mediated indirect interactions in marine communities and their conservation implications. *Ecology*, **84**, 1151–1157.

Doney, S.C., Ruckelshaus, M., Duffy, J.E., Barry, J.P., Chan, F., Grebmeier, J.M., Hollowed, A.B., Knowlton, N., Polovina, J., Rabalais, N.N., Sydeman, W.J. & Talley, L.D. (2012) Climate change impacts on marine ecosystems. *Annual Review of Marine Science*, **4**, 11–37.

Halpern, B.S., Selkoe, K.A., Micheli, F. & Kappel, C.V. (2007) Evaluating and ranking the vulnerability of global marine ecosystems to anthropogenic threats. *Conservation Biology*, **21**, 1301–1315.

Mathieson, A.C., Norton, T.A. & Neushul, M. (1981) The taxonomic implications of genetic and environmentally induced variations in seaweed morphology. *The Botanical Review*, **47**, 313–347.

Menge, B.A. & Sutherland, J.P. (1987) Community regulation: variation in disturbance, competition, and predation in relation to environmental stress and recruitment. *The American Naturalist*, **130**, 730–757.

Miner, B.G., Sultan, S.E., Morgan, S.G., Padilla, D.K. & Relyea, R.A. (2005) Ecological consequences of phenotypic plasticity. *Trends in Ecology and Evolution*, **20**, 685–692.

Molis, M., Scrosati, R.A., El-Belely, E.F., Lesniowski, T. & Wahl, M. (2015) Wave-induced changes in seaweed toughness entail plastic modifications in snail traits maintaining consumption efficacy. *Journal of Ecology*. doi: 10.1111/1365-2745.12386.

Padilla, D.K. (1998) Inducible phenotypic plasticity of the radula in *Lacuna* (Gastropoda: Littorinidae). *The Veliger*, **41**, 201–204.

Padilla, D.K. & Savedo, M.M. (2013) A systematic review of phenotypic plasticity in marine invertebrate and plant systems. *Advances in Marine Biology* (ed. M. Lesser), pp. 67–94. Academic Press, London.

Reed, T.E., Schindler, D.E. & Waples, R.S. (2011) Interacting effects of phenotypic plasticity and evolution on population persistence in a changing climate. *Conservation Biology*, **25**, 56–63.

Saunders, G.W. (2005) Applying DNA barcoding to red macroalgae: a preliminary appraisal holds promise for future applications. *Philosophical Transactions of the Royal Society of London. Series B, Biological Sciences*, **360**, 1879–1888.

Received 19 February 2015; accepted 20 April 2015
Handling Editor: David Gibson