Plasticity in patterning and gestation at the eco-evo-devo interface

Kristen A. Panfilio, Reviews Editor
School of Life Sciences, University of Warwick, Coventry, CV4 7AL, UK
kristen.panfilio@alum.swarthmore.edu
ORCID: 0000-0002-6417-251X

Most mammals give birth to live young (viviparity), while most birds, reptiles, amphibians, fish, and invertebrates lay eggs (oviparity). These gestational strategies have clear consequences for how the developing embryo is protected and nourished, whether in the womb with placenta-mediated maternal nutrition, or within a shelled egg provisioned with yolk (Ostrovsky et al., 2016; Panfilio and Chuva de Sousa Lopes, 2022). What is perhaps less expected is that some species exhibit plasticity, with the mother variously able to foster embryogenesis within her abdomen or in eggs that are fertilized upon oviposition into the external environment. Furthermore, regardless of gestational environment one might suppose that fundamental embryonic patterning, for example to establish the anterior-posterior (A-P) body axis, is sufficiently essential so as to be hard-wired for a given species. Not so with aphids. They represent a rare instance of viviparity among the insects, and this is made more striking by being a seasonal feature that also alters how core molecular components are used to pattern the embryo.

Reflecting their nearly 20-year research sojourn in the field of aphid developmental genetics, in this issue Chun-che Chang and colleagues present a new review on these remarkable features (Lin et al., 2022), focusing on the pea aphid, *Acyrthosiphon pisum*, as the model system. Early comparative work on viviparous (also known as asexual or parthenogenetic) and oviparous (sexual) development documented remarkable spatial and temporal scaling differences, heterochronic changes in mid-embryogenesis events, and distinct routes for embryonic acquisition of endosymbiotic bacteria between the two modes (Miura et al., 2003). Since that morphological account, molecular differences have also been noted, focusing on terminal system components and other well-known insect determinants for A-P patterning such as Hunchback (Bickel et al., 2013; Duncan et al., 2013a; Duncan et al., 2013b). These and further observations are now brought together in this new review that clarifies key features on A-P patterning and germline specification (Lin et al., 2022).

Inspired by the exquisite sensitivity of their cross-reacting antibody for Vasa protein (Chang et al., 2002), to detect primordial germ cells and track their migration into the developing gonad, Prof. Chang explains that he soon realized aphids' research potential. "The ovarioles of the viviparous (asexual) pea aphids are an excellent platform for studying gene expression during the entire period of development from oogenesis to embryogenesis. This is because an asexual ovariole contains both oocytes and embryos, conveniently staged in linear order." As the authors discuss, this linear staging has led to observations on novel features that differ from the well-characterized system of *Drosophila* and that set aphids apart compared to other hemimetabolous insects. In synthesizing this range of material, the authors also propose intriguing potential links between germ cell and bacteriocyte migration dynamics, for which the exact mechanisms of cellular crosstalk await investigation. This offers a fresh perspective on connections between development and the extended organismal phenotype of nutritional endosymbiosis and feeding ecology traits (*e.g.*, Rabatel et al., 2013). The authors conclude by highlighting key open questions and how ongoing innovations for functional work will deepen our understanding on the fascinating range of eco-evo-devo research topics and lineage-specific innovations inherent to aphid biology.

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