Developmental plasticity and Heterokairy

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**Abstract**

There is a resurgence of interest in using phenotypic plasticity, the potential for a single genotype to generate alternate phenotypes in different environments, as a framework in the study of evolutionary biology. The term developmental plasticity has been used to describe a more specific strand of investigation that focuses on how alterations to developmental processes and outcomes shape such environmentally-induced variation. Nested within developmental plasticity is the notion of heterokairy, the potential of a single genotype to alter the timing of a (or a set of) developmental events (e.g. onset of a particular physiological function, or components of that function), in response to a difference in external environment. Heterokairy emphasises novel phenotypic outcomes in terms of when a feature or features appear: a new phenotype is produced through new juxtapositions of form and functions at a given time, or by temporally separating previously co-expressed form and functions. Here we discuss the biological importance of heterokairy as a category of developmental plasticity. Owing to the complexity inherent in changes in timing of events occurring within the already dynamic process of development, we argue for the importance of keeping both terms, but firstly explore their histories in order to produce working definitions. Such a review for heterokairy has not been attempted previously, mainly due to different groups or traditions of investigators adopting or inventing their own terminology for such altered timing. Whilst heterokairy has been studied extensively in the morphology, behaviour and ecology of organisms, we propose that developmental physiology should be, and arguably must be, central to its study. The theoretical and logistic difficulties of not being able to truly replicate the ‘individual’ experimentally are explored as well as some of the ways these difficulties may be ameliorated if not overcome. We conclude by outlining a direction, and a set of research questions, aimed at probing the ecological and evolutionary significance of heterokairy. These include the extent to which it might provide the raw material and mechanisms involved in the origination of heterochrony (an evolutionary difference in the timing of a developmental event or process between an ancestor and its descendant). Heterokairy has been documented in a diverse array of both taxa and types of developmental event and therefore research focussed on the potential role of current adaptive responses of species to environmental change offers significant promise in elucidating the link between ecology and evolution during development.