The story of O: reply to Moya-Laraño

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In my recent review in TREE of the ecological causes of evolution [1], I used the term ‘O matrix’ to describe the variance–covariance matrix that quantifies variation in, and spatiotemporal correlations between, those elements of the environment, selective agents, that cause the association between fitness and phenotype that is called ‘natural selection’. Similar structure in the environment has long been recognised by ecologists in the spatial correlations between, for example, competition, predation and abiotic factors, that make it difficult to discern the environmental causes of the distributions of species [2–4]. However, the consequences of this structure for the process of natural selection have seldom been recognised or taken into account by evolutionary biologists.

In his interesting letter, Moya-Laraño [5] makes three points about the O matrix. The first is that the O matrix has been implicitly used in comparative analyses. This is true in a limited sense. Limited, because (i) analyses that have simultaneously examined the associations between adaptations and multiple environmental variables are unusual; and (ii) such analyses are retrospective and, therefore, run the risk of confounding the true cause of selection (and evolution) with factors that operate at an ecological level, such as plastic responses to the environment and habitat choice.

The second is that the O matrix needs to be stable. Environments vary spatially and fluctuate temporally, and it is exactly these variations that the O matrix describes. The utility of the O matrix as a concept depends not on whether the environment is stable (it is not), but on the extent to which different aspects of the environment covary in space and time. If correlations between selective agents remain similar (e.g. predation high where competition is high, or low where it is low [2]), throughout the distribution or evolutionary history of species, then O matrices are stable. The extent to which this is true is an empirical question that can only be revealed by research, but the ecological literature [3,4] suggests that O matrices are likely at least to be spatially stable.

The third point is that, in addition to the O matrix affecting the evolution of organisms and structure of correlations between traits (the ‘G’ matrix), as I suggested [1], the G matrix in turn may reciprocally affect O matrices. This is true, and an emerging theme of recent eco-evolutionary research is that organisms can shape their environments [6,7]. However, although organisms are often shaped by their environment, the effect of the organism on the environment is necessarily more diffuse: most organisms are unlikely to affect the basic physicochemical properties of the environment [8], let alone climate fluctuations such El Niño [9] or the North Atlantic Oscillation [10]. Even for humans, it seems unlikely that the exact shape of the G matrix matters very much in this regard!

References
8 White, C.R. et al. (2007) Basal metabolic rate of birds is associated with habitat temperature and precipitation, not primary productivity. Proc. R. Soc. B 274, 287–293