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Opinion

Natural Selection and Adaptive Evolution: A Functional Understanding

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Introduction

Natural selection is one of the central mechanisms of evolutionary change and is the process responsible for the evolution of adaptive features. Without a working knowledge of natural selection, it is impossible to understand how or why living things have come to exhibit their diversity and complexity. An understanding of natural selection also is becoming increasingly relevant in practical contexts, including medicine, agriculture, and resource management. Unfortunately, studies indicate that natural selection is generally very poorly understood, even among many individuals with postsecondary biological education.

Description

This paper provides an overview of the basic process of natural selection, discusses the extent and possible causes of misunderstandings of the process, and presents a review of the empirical study of survival of the fittest reveals that adaptations often involve trade-offs between competing functions. Because action acts on whole organisms instead of isolated traits, adaptive evolution could also be constrained by the interaction between traits that are functionally integrated. Yet, few attempts are made to characterize how and when such constraints are manifested or whether or not they limit the adaptive divergence of populations. Here we examine the implications of adaptive life-history evolution on locomotors performance within the live-bearing guppy. In response to increased predation from piscivorous fish, Trinidadian guppies evolve an increased allocation of resources toward reproduction. These populations are under strong selection for rapid fast-start swimming performance to evade predators. Because embryo development increases a female's wet mass as she approaches parturition, an increased investment in reproductive allocation should impede fast-start performance. We discover evidence for adaptive but constrained evolution of fast-start swimming performance in laboratory trials conducted on second-generation lab-reared fish. Female guppies from high-predation localities attain a faster acceleration and velocity and travel a greater distance during fast-start swimming trials. However, velocity and distance travelled decline faster over the course of pregnancy in these same females, thus reducing the magnitude of divergence in swimming performance between high- and low-predation populations. This functional trade-off between reproduction and swimming performance reveals how different aspects of the phenotype are integrated and highlights the complexity of adaptation at the whole-organism level. Adaptive evolution is formed by the interaction of population genetics, action and underlying network and biochemical constraints. Variation created by mutation, the staple for evolutionary change, is translated into phenotypes by flux through metabolic pathways and by the topography and dynamics of molecular networks. Finally, the retention of genetic variation and therefore the efficacy of selection depend upon population genetics and demographic history. Emergent high-throughput experimental methods and sequencing technologies allow us to collect more evidence and to maneuver beyond the speculation in numerous systems and populations.

Conclusion

Here we review the extent to which recent evidence supports long-established theoretical principles of adaptation. However, conflicting results prevent resolution of long-standing theoretical debates about the roles of hard and soft selective sweeps and also the effect on the efficiency of selection. It's possible that these contradictions are simply because of inherent difficulties in detecting sequence signatures of adaptive evolution the provision of more sequences and improved analytical methods may eventually result in more conclu-

sive results. Additionally, although some studies validate predictions from molecular network theory other examples consistently defy expectations, indicating that the results of pathway and network position on adaptive value are more complex than previously thought. More detailed studies of the functional effects of gene product interactions may shed light on these confusing patterns.

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Conflict of Interest

None