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categories, vowels, or vocal timbres). Within a single culture, it would be fascinating to reconstruct phylogenetic change over time, for example across ten centuries of Japanese *gagaku* music or religious chants in Europe (unfortunately the databases used here did not allow ancestor-descendent relationships, or mutation rates, to be determined).

In summary, we see the new work of Savage *et al.*[2] as opening an exciting new vista in the study of musical change and cultural evolution — and perhaps it will breathe new life into a hoped-for science of memetics, as Dawkins envisioned fifty years ago.

DECLARATION OF INTERESTS

The authors declare no competing interests.

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Climate change: Aerial insectivores struggle to keep pace with earlier pulses of nutritious aquatic foods

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Not all insects are created equal and those emerging from wetlands are nutritionally superior to those from uplands. Insectivorous birds have timed reproduction to coincide with insect pulses, but new work shows how climate change has disconnected this synchrony, creating reductions in insect quality with profound implications for conservation.

Determining whether and how different taxa keep pace and respond appropriately to rapid climate change represents one of the most pressing conservation challenges of our era[1,2]. One important body of work in this regard has focused on mismatches, or phenological asynchrony, between climate-induced changes in the timing of the supply of key resources and the timing of resource demands to support successful reproduction and survival in animals[3].

Several classic studies demonstrate that advancing resource peaks now occur sooner than needed in several prey–consumer systems[4]. Individuals unable to advance their breeding schedules appropriately can thus miss resource peaks, in some species leading to population declines[5]. New questions arose as theory and empirical studies

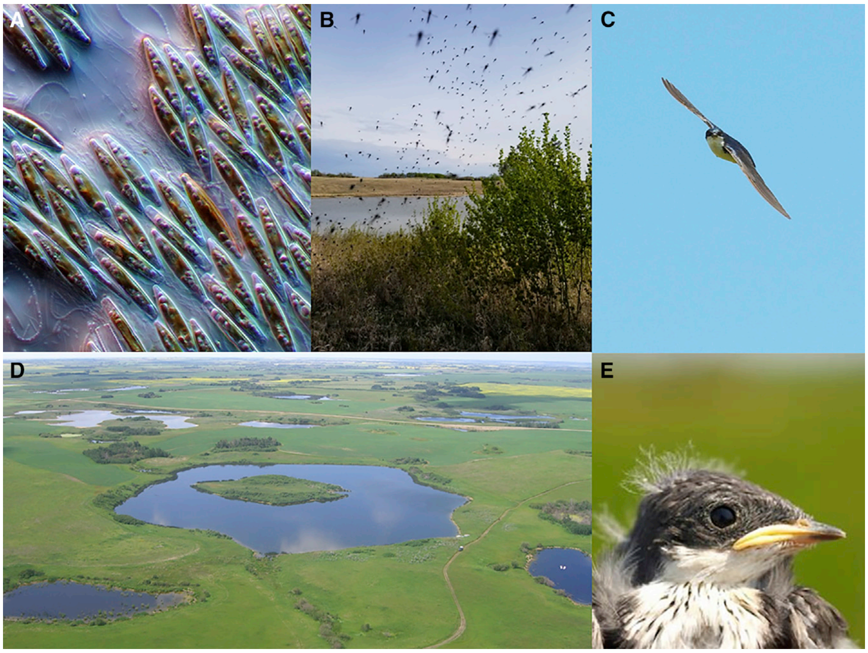

Figure 1. Unveiling nutritional impacts of climate change.
Globally, natural aquatic systems are biodiversity hotspots but are being impacted by numerous threats including climate and land-use changes[20]. Wetlands also punch well above their weight in terms of exporting nutritious foods eaten by diverse consumers, including the aerial insect-eating tree swallow (*Tachycineta bicolor*) — one of the species studied in the new work by Shipley, Twining *et al.*[11]. Although tree swallows have advanced breeding dates with climate warming, their response has not kept pace with more rapid advances in the emergence of aquatic aerial insects that contain key beneficial fatty acids. (A) Freshwater diatoms produce beneficial fatty acids and are eaten by insect larvae during aquatic life stages (image courtesy of MarekMiś/Wikimedia Commons (CC BY 4.0)). (B) Emerging aquatic chironomids (image by R. Clark). (C) Adult tree swallow (image courtesy of C. Hendrickson). (D) Palustrine wetlands in Saskatchewan farmland (image courtesy of M. Bidwell). (E) Tree swallow nestling (image courtesy of C. Hendrickson).

matured, specifically by asking for the correct 'yardstick' to measure resource mismatches[6,7].

More recently, investigations into the nutritional *quality* of diets rather than biomass per se has raised the importance of considering 'nutritional landscapes' or identifying nutritional hotspots that assist birds in provisioning their offspring with nutrients key to their development or pending migration[8]. This emphasis on nutritional physiology provides a means of better understanding the consequences of phenological shifts due to climate change[9]. Prominent among avian guilds highly affected by changes in insect prey composition during breeding are the aerial insectivores, especially the swallows and martins, a guild that has experienced dramatic declines over the last decades[10] (Figure 1).

In a paper published in this issue of *Current Biology*, Shipley, Twining and associates[11] have shed new light on the vulnerability of aerial insectivorous birds to changes in emergence of insects by focusing on the role such insects play in providing key fatty acids, especially to their developing nestlings. Importantly, they evaluate the consequences of the differential availability of highly unsaturated fatty acids (HUFAs), particularly eicosapentaenoic and docosahexanoic fatty acids. By far, aquatic emergent insects contain higher concentrations of these beneficial HUFAs compared to terrestrial insects.

By integrating long-term data for climate-related shifts in the phenology of aquatic and terrestrial aerial insect emergence and the timing of breeding in a guild of insect-eating birds, Shipley, Twining *et al.*[11] show that emergence of HUFA-rich aquatic insects has advanced more rapidly than HUFA-deficient terrestrial insects. Because several aerial insectivorous bird species have not advanced breeding dates to keep pace with the emergence of aquatic insects, these species increasingly face a nutritional disadvantage when raising offspring. In support of this pattern, there is growing evidence in other avian study systems that aquatic insects and availability of ponds can improve swallow offspring growth and recruitment[12,13].

The export of biomass and nutrients between terrestrial and aquatic systems has been well-quantified in numerous systems worldwide[14,15]. Shipley, Twining *et al.* extend this field and illustrate the substantial imbalance in HUFA export in their system, for example, with aquatic insects producing more than an order of magnitude greater eicosapentaenoic acid supply than do terrestrial species during crucial stages of the breeding cycle.

The importance of this work cannot be overstated given the pace of climate change. Indeed, because the authors looked primarily at insect biomass, their estimates of the consequences of phenological shifts may be conservative — availability of terrestrial prey to aerial insectivores may actually be lower than those that emerge en mass from aquatic systems and further refinements might include differential weighting of such availability. As the authors are also aware, some species may be able to convert precursors available in terrestrial insects to omega-3 fatty acids efficiently and so suffer less when their diets incorporate more terrestrial insect sources[16]. In this sense, barn swallows (*Hirundo rustica*) may ultimately have an advantage over the more riparian swallows and martins[17]. Renewed interest in using stable isotope methods to trace consumer use of aquatic versus terrestrial insects, both via bulk and compound-specific approaches, will undoubtedly contribute to further refinement of climate change impacts on a broad range of taxa[13,18]. Furthermore, generalizing Shipley, Twining *et al.*'s results to other systems, while also quantifying phenology–fitness relationships, could improve predictions about the nature and likely consequences of climate-induced prey–predator asynchronies[9,19].

Globally, loss and degradation of wetlands continue due to agricultural expansion and urbanization, creating adverse impacts on insects and species that rely on insect resources[20]. Concerted efforts guided by strong science are urgently needed to inform wetland conservation efforts. In this regard, better quantifying how aquatic-derived foods infiltrate and support terrestrial food webs could strengthen the weight of evidence for the importance of wetlands in sustaining biodiversity in human-altered landscapes (Figure 1).

DECLARATION OF INTERESTS

The authors declare no competing interests.

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Cell division: *Naegleria* bundles up for mitosis

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How well do we understand the range of mechanisms used by eukaryotes for mitosis? A new study in a highly divergent eukaryote shows that unusual tubulin isoforms can create a mitotic spindle exclusively out of microtubule bundles.

Most of the model systems used to study mitosis fall within a very narrow branch of the eukaryotic family tree known as the opisthokonts, which includes mammals, insects, and yeasts. While the mitotic mechanism among opisthokonts is well conserved, there are points of divergence, such as whether the nuclear envelope is preserved or breaks down[1]. Recent genomic surveys have shown that the bulk of eukaryotic diversity is found within single-celled protists that are highly diverged from opisthokonts and have only been widely studied in the last fifteen years or so[2]. To distinguish between the foundational, invariant aspects of mitosis that are essential for its function and the lineage-specific adaptations of this process, it is necessary to survey the mitotic mechanisms of a much broader range of eukaryotes[3]. A new study by Velle *et al.*[4], published in this issue of