mammalian evolution[2,3]. This mechanism likely builds upon ancient vestibulo-ocular and optokinetic reflexes[11], adapted to the particular needs and visual capabilities of different species while maintaining the core function of stabilizing optic flow patterns during movement.

Of course, the Wallace *et al.*[1] study only reveals one piece of the larger puzzle of how vision operates during natural behavior. Ferrets were only studied in two specific conditions: running straight or turning towards a ball rolling away. Different scenarios might engage different mechanisms. For instance, initiation of a pursuit might rely more on a 'saccade-and-fixate' strategy initially, while tracking an incoming or erratically moving target could involve other distinct eye–head coupling. Beyond these specific findings, this study exemplifies a shift in neuroscience: moving from head-fixed preparations to understanding how animals actively sample their world during natural behaviors. By reconstructing what animals see as they move, we gain insight into how multiple neural systems — vestibular, motor, visual — must be coordinated to create coherent perception during action. The integration of these systems during pursuit suggests that many fundamental principles about sensory processing may only emerge when studied in more natural contexts. Understanding how neural circuits process and integrate self-generated sensory signals during ethologically relevant, natural behaviors may reveal new fundamental principles of visual systems.

DECLARATION OF INTERESTS

The author declares no competing interests.

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Hawaiian love songs: Coevolutionary conflict between mate attraction and parasite escape

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The recent introduction of an acoustic parasitoid fly to Hawaii has profoundly disrupted the singing behavior of the Island's only field cricket, resulting in a coevolutionary arms race involving rapid alteration of both the songs the crickets produce and the ability of eavesdropping flies to hear the songs.

Parasitoid insects differ from other parasitic animals because their host serves as a living incubator within which the parasitoid's eggs and larvae grow and develop. When the developing larvae mature they burrow out of the body, invariably killing the host — parasitoids are more like predators than parasites. Humans do not have parasitoids but if they did, it would play out like the extraterrestrials that gruesomely invaded human bodies as depicted in the horror movie *Alien*. Of particular interest here is the interaction between parasitoid flies and their cricket hosts. On the mainland of the subtropical and tropical Americas a stable symbiotic relationship exists between the acoustic parasitoid fly *Ormia ochracea* and its host, a field cricket of the genus *Gryllus*[1,2]. *Ormia* locates its host by eavesdropping and homing in on the male cricket's reproductive calling song. It has an acutely sensitive hearing organ that is sharply tuned to the 4–6 kHz dominant spectral frequencies of the *Gryllus* reproductive calling songs[1,2].

Evolutionary biologists know that isolated archipelagos, like Hawaii, are hotbeds of novel evolutionary events such as endemic speciation, and now another fascinating evolutionary scenario is unfolding there. *Ormia* was recently and inadvertently introduced to the Islands where it encountered a new host, the Pacific field cricket, *Teleogryllus oceanicus*, which does not occur on the parasite's homeland. *T. oceanicus* had inhabited the Islands long before recorded history, for perhaps thousands of years; it is the island's only common field cricket. *Ormia*'s appearance in Hawaii was not known until 1993[3] and it is presumed to have invaded the Islands not too long before. In the three decades since its first reported appearance, however, *Ormia* populations have exploded, sweeping through the Islands with devastating effect on the acoustic behavior of *T. oceanicus*, particularly on Kauai, where *T.oceanicus* has fallen silent — the reproductive sounds of calling crickets are gone from Kauai's evening soundscape[4].

With no alternative cricket hosts, the full force of *Ormia*'s attention is focused unrelentingly on *T. oceanicus*. Nonetheless, within the past 10 years, populations of *T. oceanicus* have been discovered that still sing calling songs but these are highly modified from the original species call[5,6], presumably as an adaptation to escape detection from their eavesdropping parasites. But if the island's mutant calling crickets are successful in escaping parasitism, what then happens to their eavesdropping parasitoids? As they report in this issue of *Current Biology*, Wikle *et al.*[7] have tackled this question and found that, although the crickets are modifying the frequency (pitch) of their songs to escape fly detection, the flies are shifting their auditory pitch sensitivity to closely match the novel songs of their hosts, also within this decade. This point–counterpoint struggle is apparently playing out in real time, and Wikle *et al.*[7] present 'snapshots' of this rapidly unfolding coevolutionary struggle. Their data are evidence of early stages in the interaction between fly and cricket in Hawaii, where intense and disruptive selective pressure has resulted in an arms race focused on their senses of hearing.

The experiments carried out by Wikle *et al.*[7] range from lab to field experiments on flies and crickets in Hawaii and include neurophysiological laboratory studies to test auditory sensitivity of *Ormia*, as well as lab experiments to measure their behavioral response to playback of pre-recorded Hawaiian crickets and other precisely controlled acoustic stimuli. First, they compared the auditory sensitivity of the Hawaiian flies to the auditory tuning of ancestral, mainland *Ormia* from lab stocks originally obtained in Florida. Their data show that the auditory tuning curves of derived Hawaiian flies have distinctly diverged from the ancestral flies and, further, that the difference is due to genetic and not environmental factors, such as learning or priming. Specifically, the auditory tuning of ancestral flies is sharply tuned, peaking at about 5 kHz, which matches the dominant frequency of the songs emitted by most species of field crickets of the genus *Gryllus*, their mainland hosts. In contrast, the Hawaiian flies have shifted as well as broadened their auditory thresholds, enabling them to hear sounds over a much wider band of higher frequencies, ranging from 6–20 kHz. Parallel field studies in Hawaii[5,6] have uncovered *T. oceanicus* populations that have retained their ability to broadcast calling songs, such as the 'purring' and 'rattling' variants. These are mutant strains and they sing highly modified calling songs that diverge strongly from the ancestral, pre-*Ormia* invasion, Hawaiian *T. oceanicus* song. The purring and rattling mutant songs exhibit broad spectral frequency shifts toward high frequencies ranging from 6–20 kHz, although the particular spectral peaks may vary over that range from individual to individual, within each mutant cricket strain[5].

Remarkably, when the frequency tuning in the auditory system of Hawaiian *Ormia* is compared to the spectral peaks in songs of these *T. oceanicus* mutant strains, it appears that the auditory sensitivity of the parasitoid fly is changing 'in step' with the host cricket's capacity to modify the spectral characteristics of its calling song through mutation. While this correlation is tantalizing, the proof of the pudding requires behavioral testing. Are Hawaiian flies attracted to the mutant purring and rattling songs when they hear them? Wikle *et al.*[7] performed phonotactic choice experiments by placing a tethered, live fly on the surface of a spherical treadmill (based on a common computer trackball) and positioning audio playback speakers to the right and left of the front-facing fly. In this way, the investigators could measure the turning tendency of the fly by its walking movements when sonically stimulated with pre-recorded songs or electronically synthesized signals like white noise or audio-avatars of cricket songs. They found that the derived Hawaiian *Ormia* were much more responsive to playbacks of derived purrs/rattles than were the Floridian *Ormia*. The phonotactic behavior of Hawaiian *Ormia* thus corroborates the neurophysiology data showing a high-frequency shift in their auditory tuning curves had occurred.

The song-shifting to higher frequencies is presumably an acoustic gambit by *Teleogryllus* to escape *Ormia*'s unrelenting pressure on its reproductive acoustic behavior — but there's more. Wikle *et al.*[7] also report that mutant songs, like purring and rattling, are much less intense in sound level (softer) than the ancestral *Teleogryllus* calls. But reducing the call's sound level will shorten its 'reach' for attracting conspecific females[5]. Moreover, it is surprising, if not astonishing, that the purring and rattling mutants have evolved just within the past decade. In field experiments on Hawaii, the investigators deployed loudspeakers that broadcast mutant and natural *Teleogryllus* songs at typical sound levels to determine if *Ormia* would be attracted to their acoustic avatars of their hosts. They found that, while flies were attracted in much greater numbers to the typical *Teleogryllus* call (which is naturally much louder), a lesser but significant number of flies were also attracted to both purring and rattling song playbacks — which were broadcast at the softer sound levels that reflect their natural intensity.

Clearly, the mutant calls are loud enough to trap a significant number of flies despite their reduced sound level. Wikle *et al.*[7] also devised a computational model that predicts the distances over which the derived, modified songs such as purring, rattling, and ancestral flies would attract flies — an insightful exercise that confirmed the actual performance of flies and crickets, in the field and in the lab. In particular, the diminishing sound level, or loudness, of modified songs has strong effects on their 'drawing power' to attract eavesdroppers as well as potential mates.

The new Wikle *et al.*[7] study is exceptional in its scope and thoroughness, but there remains more to be explored in this study system, such as the role of the pattern, or rhythm, of sound pulses that are unique to the stereotyped call of *T. oceanicus*, which is known to be key for its attractiveness as a sexual signal[8]. Whether alterations in song rhythm occur in Hawaiian *Teleogryllus* calls is certainly an issue for future studies of the crickets as well as the flies.

Neither the genetic nor the physiological mechanisms that underlie *Ormia*'s rapid shift in its auditory system are known. There is also an issue here for the mutant crickets: if mutant males sing modified calls, there must be matching changes in the auditory system of conspecific females if the altered call is to retain its function as a reproductive signal. In crickets, there is recent strong evidence supporting genetic coupling between song and preference[9]. However, the acoustic coupling between cricket and fly reported here cannot be due to genetic coupling, as it is for the crickets themselves. But rapid coupling could arise from phenotypic variability in the auditory sensitivity of Hawaiian flies, as a result of environmental or developmental processes. This phenotypic plasticity[10], where a given genotype could give rise to multiple phenotypes, could help explain the rate at which the fly–cricket acoustic interaction is unfolding on the Islands.

The role of phenotypic plasticity has been raised in the context of the evolution of Hawaiian *Teleogryllus*[11]. In Hawaii, we are witnessing the unfolding of adaptive trade-offs pitting the forces of natural selection against sexual selection[12]. The former stems from the inevitably fatal consequences of infestation of *Ormia* on its host. The latter requires that any adaptive changes in a male cricket's song must be genetically coupled to corresponding changes in song preferences in conspecific females. Wikle *et al.*[7] have shown that this interaction must reckon with rapidly adapting changes in the auditory perception of flies, which appear to be keeping up with the escape gambits of its host.

DECLARATION OF INTERESTS

The author declares no competing interests.

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Alcohol use: Passing out has long-term effects on sleep

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Sedative doses of alcohol consumption paradoxically cause long-term sleep deficits in humans. A study in *Drosophila* reveals similar sleep deficits in flies following ethanol sedation and uncovers a subset of cholinergic neurons that mediate this effect.

Most persons with alcohol use disorder — alcoholics — suffer from sleep deficits. After some heavy drinking they might eventually pass out, but then they sleep lightly for the rest of the night[1]. Beyond the acute effects of a hangover, this often has long-lasting consequences on their cognitive functions and emotional balance[2]. Whether it is defective sleep or the direct effects of excessive alcohol itself that causes chronic problems remains unclear and difficult to determine in humans. In this issue of *Current Biology*[3], Chvilicek and colleagues uncover similar effects of excessive alcohol consumption on sleep in fruit flies, giving hope that a mechanistic understanding of the link between alcohol use disorder and sleep could be resolved in the *Drosophila* model.

Surprisingly, a single exposure to volatile ethanol was enough to cause flies to lose sleep over multiple days and nights. It was important, however, for the ethanol to be sedating, meaning that flies passed out, or in clinical language, display