transport the enormous heat flux that they radiate into space, will trigger waves and turbulence in the atmosphere[7,8] that could potentially organize into coherent, large-scale weather features such as those seen in Crossfield and co-workers' maps. Jupiter's Great Red Spot — a vast, centuries-old vortex — and Saturn's recent massive convective storm[9] provide useful analogies.

That said, it is currently unclear how far the analogy with Jupiter extends. Although brown dwarfs are Jupiter-like in many ways, they radiate heat fluxes that are orders of magnitude greater. Recent work[10] suggests that, under these radiative conditions, the atmospheric circulation may comprise turbulence and vortices with no preferred directionality, rather than a banded pattern with multiple east–west jet streams like that of Jupiter and Saturn. Unfortunately, Crossfield and colleagues' analysis does not resolve this crucial issue; a well-known bias makes it a particular challenge to confidently infer banded patterns with the Doppler-imaging technique. Still, future attempts will be welcome, and, if successful, they could have implications for the interpretation of brown-dwarf variability as well as theories of atmospheric dynamics generally, including the multi-decade effort to build a theory for Jupiter's and Saturn's jet streams.

There are other caveats. The signal-to-noise ratio in the authors' maps is modest, and only a few of the largest atmospheric structures in the maps are statistically robust. The observations — which are based on carbon monoxide spectral lines at a wavelength near 2 micrometres — do not establish whether the patchiness results from spatial variations of clouds, temperature or chemistry, although the first is most likely, and observations at other wavelengths can break this degeneracy. Moreover, because Luhman 16B and its companion are the brightest brown dwarfs in the sky, they are the only ones to which the Doppler-imaging technique can currently be applied. Despite the caveats, these are exciting times for brown-dwarf science. The next few years should see the workings of these fascinating worlds gradually come into focus. ■

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EVOLUTIONARY BIOLOGY

Brotherly love benefits females

Mating competition between males often has harmful consequences for females. But it seems that fruit flies alter their behaviour among kin, with brothers being less aggressive and females reproducing for longer as a result. SEE LETTER P.672

SCOTT PITNICK & DAVID W. PFENNIG

The romantic notion of sexual reproduction as a cooperative endeavour has been trampled on by a growing number of cases in which sexual competition between males results in harm to females[1]. Examples include spiny-beetle penises that punch holes in the female reproductive tract, female frogs drowning as several males struggle to mount them, and toxic ejaculate proteins that reduce a female fruit fly's desire to re-mate and can cause her early death. Such costs incurred by females represent the collateral damage of male–male competition for access to successful reproduction[2]. But the picture is complicated when the competing males are related, because of the evolutionary benefit to an individual if a relative reproduces. Theory suggests that male relatedness should reduce sexual harm to females. In this issue, Carazo *et al.*[3] (page 672) show experimentally that this is indeed the case in the fruit fly *Drosophila melanogaster*.

Sexual harm to females is a 'reproductive tragedy of the commons' that may reduce a population's productivity and even lead to local extinctions[4]. But conflict and cooperation in social interactions lie along a continuum, and resolving the evolutionary pressures that move populations along this continuum is a major challenge. One such pressure is genetic relatedness among males. Natural selection favours individuals that are most successful at propagating their distinctive genes; these individuals are said to have the highest 'fitness'. However, an individual's overall ('inclusive') fitness is the sum of its direct fitness, which is the number of offspring it produces, and its indirect fitness, which includes the number of offspring produced by the individual's genetic relatives as a result of its behaviour. Essentially, by helping its genetic relatives to reproduce, an individual indirectly

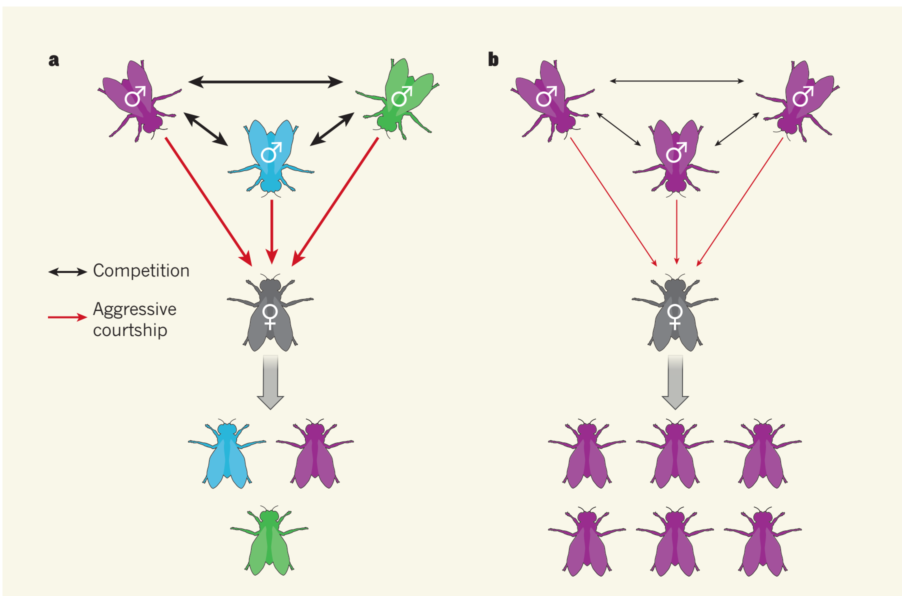

Figure 1 | Kindness to kin reduces harm to females. **a**, Unrelated male fruit flies compete with each other and court females aggressively. Carazo *et al.*[3] find that this behaviour harms females by causing them to age rapidly (in reproductive terms) and ultimately to produce fewer offspring. **b**, By contrast, the authors observe that brothers compete and court less aggressively; consequently, the females are reproductively successful for longer and produce more offspring. This reduced aggression between brothers also benefits the males: by helping his brothers to reproduce, a male indirectly propagates copies of some of his own genes.

propagates copies of some of its own genes[5].

It has been proposed that kin selection — natural selection that increases indirect fitness — can explain why males sometimes reduce the harm incurred by their mates[4,6]. Specifically, when kin compete, any harm imposed on a female should detrimentally affect the males' inclusive fitness by reducing the reproductive output of their male relatives. So, by favouring reduced competition between related males, kin selection should limit collateral harm to females. Although sexual cooperation between related males has been extensively studied in vertebrates[7,8], the fitness consequences for females have received little attention.

In a series of experiments, Carazo *et al.* paired one female with three males that were unrelated to the female, but that varied in relatedness to one another. The authors found that females paired with male triplets that were full siblings (AAA) had greater lifetime reproductive success than females paired with three males that were unrelated to each other (ABC). This difference was not a result of AAA-treatment females having higher fecundity or a longer lifespan, but rather because they exhibited reduced reproductive senescence — that is, their rate of offspring production declined with age more slowly than did that of females exposed to unrelated males. The researchers show that this pattern was attributable, at least in part, to a significantly slower decline in the survival of offspring as AAA- compared with ABC-treated females aged (Fig. 1).

The authors next sought to uncover the mechanisms underlying the reduced reproductive senescence of females when paired with brothers, by quantifying how males interact with the female and with one another. Again, females were randomly assigned to AAA or ABC trios of males, with the addition of a third, intermediary treatment of two full siblings and one unrelated male (AAB). As predicted by kin-selection theory, fighting between males was more common in ABC triplets than in either of the other conditions (Fig. 1). ABC males also courted females more intensely than AAA males. However, there were no treatment-related differences in mating rates. These observations suggest that harm to females is mediated by the aggressive behaviour of unrelated males towards each other and to females, reinforcing earlier findings[9].

One might propose that ABC males harm their mates by adjusting the contents of their ejaculate. For example, the seminal-fluid hormone Acp70A can reduce female lifespan, and *D. melanogaster* males are adept at facultatively adjusting both the sperm and seminal-fluid content of their ejaculates[10,11]. But Carazo *et al.* ruled out this explanation. They quantified female post-mating behaviours that are influenced by ejaculate content (latency to re-mating, and egg-laying rate) and found no differences between females inseminated by AAA compared with ABC males. Thus, the beneficial consequences of kin selection seem to involve pre-mating sexual selection. Nevertheless, another experiment revealed dramatic post-copulatory consequences of male competitive behaviour. By combining two brothers with one unrelated male (AAB), the authors found that the unrelated male did not court or mate more frequently than either of the brothers, yet sired on average twice as many offspring! Although the mechanism underlying this dramatic pattern remains a mystery, the evolutionary implications are clear: the gentler behaviour among brothers that reduces premature ageing of females is evolutionarily unstable. Such kindness will not be rewarded whenever selfish, unrelated males join the group.

Drosophila melanogaster has been an important model system for studying myriad topics in evolutionary biology, including sexual selection and sexual conflict, but not kin selection. Natural fruit-fly populations are typically large, and individuals are thought to disperse widely within their environment, so there would presumably be little opportunity for interaction among relatives. Yet Carazo and colleagues' findings suggest that *D. melanogaster* populations might occasionally be (or have been) structured such that they could be influenced by kin selection. We hope that this surprising and compelling study will tempt more *Drosophila* biologists to leave the laboratory to explore the ecology of this model system. ■

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ATOMIC PHYSICS

Polar exploration

Magnetic monopoles — particles carrying a single magnetic charge — have never been seen. Analogues of these entities have now been produced in an ultracold cloud of rubidium atoms. **See Letter p.657**

LINDSAY J. LEBLANC

If you have ever broken a magnet in two, you will know that each of the new pieces has a 'north' and a 'south' pole — just like the original. Despite being allowed in theory, a north pole separated from its south to create an isolated magnetic monopole has not been found. On page 657 of this issue, Ray *et al.*[1] report how they have created a 'Dirac monopole' by engineering an environment that mimics a monopole's magnetic field in a cloud of rubidium atoms. Using direct imaging, the authors observe a distinct signature of the Dirac monopole in this quantum system: a line of zero atomic density that pierces the cloud and terminates at the monopole. This 'Dirac string' is a defect that allows the system's quantum-mechanical phase to satisfy constraints imposed by the monopole's characteristic geometry and the wave-like nature of matter.

The duality of electric and magnetic fields in classical electromagnetism makes it especially surprising that no magnetic monopole has been found to complement the electric charge. In his 1931 paper[2], Paul Dirac showed that the theory of quantum mechanics, like its classical counterpart, allows the existence of monopoles. Furthermore, he demonstrated that if even a single monopole exists, electrical charge must come in discrete packets, which provides a possible explanation for the well-established observation that electrical charge is quantized. Although experiments have failed to find definitive evidence for the magnetic monopole[3], researchers continue to seek this elusive particle with ever more powerful tools (see, for example, refs 4–6).

To explore the quantum properties of matter near a monopole, Ray and colleagues used a Bose–Einstein condensate (BEC) of ultracold rubidium atoms. A BEC is a collection