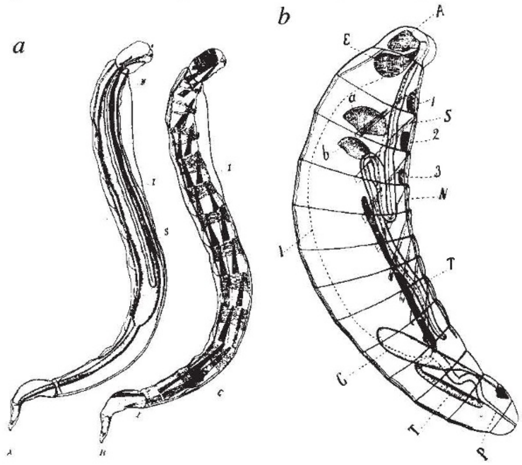
are female and only 200 male.

It makes good evolutionary sense that mixed broods contain fewer males than females. Suppose that all the adult female wasps hatching from the caterpillar are mated by their brothers, and that the mating opportunities for males away from the brood are insignificant. The clone of male larvae will be selected to multiply to produce just enough individuals to mate with their sisters. What is more, natural selection will operate in exactly the same way on any genes expressed in the female larvae or the parent that influence sex ratio. In other words there are no genetic conflicts of interest between parent, sons and daughters.



Precocious (left) and normal (right) larvae of the polyembryonic wasp *Copidosoma (=Litomastix) truncatella* (two figures not to scale). The figures are taken from Silvestri's article[1], in which he described for the first time the larval polymorphism and the fate of the precocious larvae.

But if males are able to obtain a significant number of matings away from their natal brood, conflicts of interests rear their heads. Natural selection acting on genes expressed in the male larvae will favour a larger male clone size to capitalize on the opportunities to mate with other females in the environment. However, natural selection acting on genes expressed in the female clone will favour a reduction in the size of the male clone to reduce competition for the limited resources that constitute the host. The difference in evolutionary optima is heightened by a genetic asymmetry common to all haplodiploid organisms. There is a greater probability that a gene present in a male is also present in his sister, than that a gene present in a female is also present in her brother. In other words, a male cares more for his sister than a female does for her brother.

It is against this background of potential evolutionary conflict between male and female clones that the experiments of Grbić *et al.* are particularly interesting. They found two sexual asymmetries in development. First, and against all expectations, precocious larvae are almost exclusively female. Second, while female clones develop freely in the host thorax, male clones are hidden in fat tissue in the host abdomen. Moreover, *in vitro* the female precocious larvae attack developing male clones, but not female clones or host tissue. The function, or at least one of the functions, of precocious larvae thus seems to be the manipulation of brood sex ratio in favour of the female clone.

Whether the activities of the precocious larvae mean that the evolutionary conflict is decided in favour of the female clone is still not clear. A detailed quantitative comparison of the observed outcome with the optimum brood size and sex ratio from the point of view of the two clones is required to resolve this question. It is possible that proliferation within the male clone, partly protected in the fat tissue, manages to balance losses from female attack so that the outcome is in fact nearer the male optimum.

In general, the study of evolutionary conflicts within the family has two stages. The first stage (usually the easier) is the delimitation of the battleground, typically by comparing the evolutionary optima for the two combatants. The second is the prediction of the resolution of the conflict, which is much harder as it normally requires a detailed understanding of the coevolutionary interactions between the two participants. Because of their experimental tractability, polyembryonic wasps may provide an ideal model system to study the resolution of an evolutionary conflict.

In *The Selfish Gene*, Dawkins[5] notes that no feats of "heroic self-sacrifice" are recorded from broods of polyembryonic nine-banded armadillos but that "it would be well worth somebody's while going to South America to have a look". An entomological chauvinist would point out there is no need for that, as both heroic self-sacrifice and the most devilish of selfish genery can be found in the polyembryonic wasps that parasitize the caterpillars in most people's gardens. □

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DAEDALUS

Metal blowing

Metals and their alloys are usually crystalline. Ultra-fast cooling can produce amorphous, glassy metal in tiny amounts, much prized for its distinctive properties. Daedalus now proposes to make it in bulk. His scheme depends on the fact that the electrical resistance of almost every metal rises on melting.

Imagine, he says, a molten metal carrying a current; and imagine a small crystal forming within it. Its lower resistance will divert the current preferentially through itself, forming a local short-circuit. The resulting concentration of heat could melt the crystal again. So a suitable current could prevent a metal or alloy from crystallizing as it cooled. The tiny crystal nuclei, essential to start the process, would be obliterated as fast as they formed. Ultimately, the metal would get too cold to crystallize at a detectable rate. The current could then be turned off and the product quenched to room temperature. A supercooled liquid, a true metallic glass, would result.

DREADCO's metallurgists are now melting all sorts of alloys in a modified induction furnace, and slowly reducing (but not shutting off) the current. With proper control, the current-carrying metal should solidify in glassy form. The resulting alloys should have all sorts of interesting new mechanical, chemical and magnetic properties.

For a start, they might have a very wide range of useful compositions. The craziest random assortment of scrap metals, quite incompatible if melted into a crystalline alloy, should solidify in the induction current-field as a perfectly homogeneous and useful metallic glass. Furthermore, a really complicated mixture of metals should have a very low effective melting point. As a glassy alloy, it should soften to a viscous liquid which could be shaped, moulded or even blown at not much above room temperature.

Once metal can be blown like glass, hollow metal objects from teapots and kettles to car bodies and airframes could be blow-moulded in one operation, simply by scaling up standard glass-working techniques. At the highest moulding temperatures, the metal might begin to crystallize again; but that could be an advantage too. If the hot product were 'seeded' at one point by a single crystal at the desired orientation, the crystallization front would spread uniformly through the whole mass. The resulting structure, however complex, would consist of one single grainless metallic crystal. DREADCO metallurgists are divided as to whether it would be immensely strong or absurdly flexible. Either way, exciting new engineering techniques should open up.

David Jones