FAUNA

A SMART LITTLE WASP

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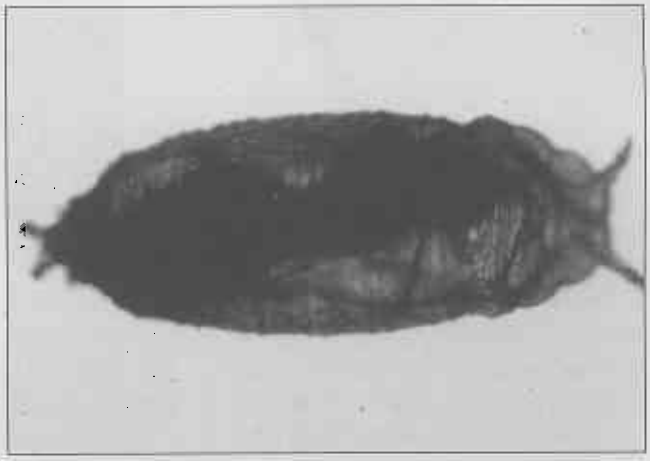
1. Phaenocarpa persimilis *laying an egg in a* Drosophila *larva. The thin ovipositor is guided by the tip of the ovipositor sheath.*



2. A Drosophila melanogaster *pupal case containing a* P. persimilis *ready to hatch. The wasp uses its large jaws to bite its way out of the pupa.*

PARASITES are not generally considered a suitable topic for polite conversation. When asked, most people would probably think of the tapeworm, several species of which can live in humans. They attach themselves to the wall of the small intestine, and like many parasites have no obvious sensory or locomotory organs, and in fact have no mouth or intestinal tract; they absorb nutrients through their surface by diffusion, and their bodies are adapted for little else than using this nourishment to make gametes. The tapeworm embryos develop in an intermediate host, such as a cow or sheep, and they are totally dependent on the infected (raw or undercooked) meat or other organs being eaten by a human to complete their life cycle.

But it is not universal that parasitic animals will always show regressive anatomy, physiology and behaviour. Ants, bees and wasps (order Hymenoptera) are possibly the most highly developed of all insects, with many species showing sophisticated navigation, learning and memory, and social behaviour. Many wasps are parasitoids, that is they have parasitic larval stages, but true to their family tree and in contrast to many other parasites, they use a variety of complex behaviours to find their hosts and sophisticated physiology to complete their life cycles. One Australian example is *Phaenocarpa* (sometimes known as *Asobara*) *persimilis*, whose hosts are the famous *Drosophila*, commonly called vinegar flies.

This common name derives from the fly's attraction to fermenting fruit, including wine, which may be contaminated by bacteria on the fly's body and hence turn to vinegar. But the fly's fame, amongst scientists at least, is because of its ubiquitous use as a subject in the study of genetics, and more recently many other areas of biology as well. There can be few universities in the world which do not have a selection of *Drosophila melanogaster* cultures in a lab somewhere, and there may be more scientific papers published on this one species than any other.

Although most of the hundreds of *Drosophila* species have a limited distribution (roughly half of them are found only on the Hawiian Islands), a few have spread around the world with human urbanisation, so we call these cosmopolitan species. They are stout insects about two millimetres long. The adults typically lay their eggs in rotting fruit and vegetables, in which the maggot-like larvae burrow and eat. Generally the larvae climb clear of the rotting material to pupate. In favourable conditions, for example in laboratory culture, the entire life cycle from egg laying to eclosion (the adult fly hatching out of the pupal case) takes less than two weeks.

P. persimilis belongs to the family Braconidae, whose members all parasitise other insects. The adult is more lightly built than its host, and is uniformly brown/black. The female is attracted to the same fermenting vegetable matter which the flies breed in, and as it walks over the surface it feels for vibrations from the *Drosophila* larvae feeding underneath. When it detects one, the wasp probes the substrate with its long, flexible brown ovipositor, guiding it through the tip of the ovipositor sheath, until it "hits" the larva. Generally the larva responds violently, but before it can burrow away the wasp injects an immobilising chemical and the larva goes limp. The wasp lays a transparent banana-shaped egg, and in about a minute the larva "wakes

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up" and carries on feeding, showing no immediate ill-effects from the operation.

The wasp egg hatches into a grub which lives within the *Drosophila* larva, slowly consuming its internal organs. When the fly pupates, the growing parasite consumes the entire contents of its host's body and eventually pupates inside the fly's pupal case. About two weeks after pupation, the adult wasp bites its way out of the pupal case.

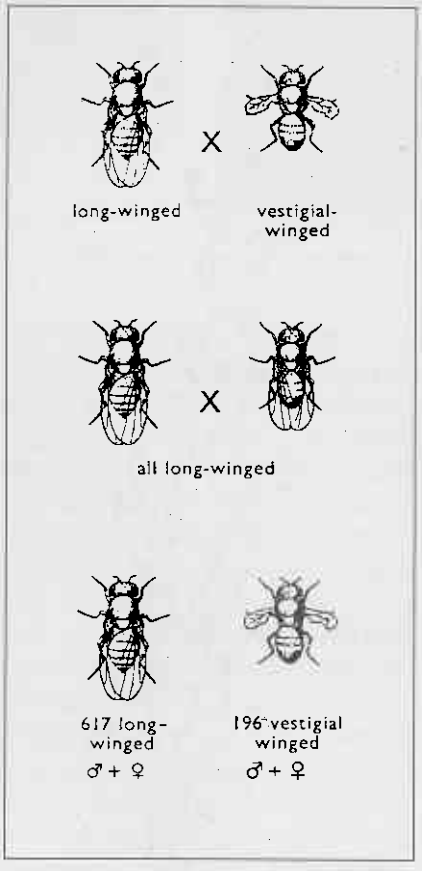
If we could empathise closely enough with the fly, we might find a *P. persimilis* grub as repulsive as a tapeworm taken from our own digestive tract, but where insects are involved most of us are happy to take a more detached view and can appreciate the adaptations which make this wasp species successful.

In ideal conditions adult *P. persimilis* can live for up to two months, but in nature it's typical lifespan is liable to be a lot less than this. At hatching the female contains 300 - 400 eggs, and she wants to find as many hosts as possible as soon as possible. To avoid wasting time in areas where hosts are rare, she searches non-randomly, spending more time in places where the host density is higher. The behavioural mechanism involved may in fact be simple - the more hosts she finds, the greater her tendency to make sharp turns in her seaching pattern.

One *Drosophila* larva represents just enough food to support one full-sized *P. persimilis*. This fact has prompted some of the most impressive adaptations by the wasp. The first of these is demonstrated by the female when she finds a host. Despite the fact that just the tip of the ovipositor enters the larva, she can tell if it already contains a wasp egg or grub. Unless most of the hosts she finds have already been "used", she will avoid laying an egg in them.

The physiology of the developing wasp shows why this behaviour is so important. Where two parasites are found in one host, the older one almost invariably kills the younger, so an egg laid in a parasitised host will almost certainly be wasted. The developing wasp also faces challenges from the host which it has to overcome. Insects have a primitive (compared to mammals) "immune" reaction, where foreign bodies are recognised and surrounded by blood cells, which then lyse and adhere to form an enclosing capsule. Melanin is deposited in this capsule, which can persist from the larval stage through to the adult, where it can usually be seen near the surface of the abdomen. Both eggs and larvae of *P. persimilis* totally circumvent this process - apparently they are just not recognised as foreign.

Another challenge for the wasp grub is to grow inside its host without preventing the host from growing and pupating normally; in this it seems always to be totally



3. Drosophila *from the Year 11-12 text "The Web of Life".*

successful. It manages this by targetting non-critical organs, such as the fat body, first, and avoiding any vital organs until the pupa is fully formed. This delicate diet selection is an impressive ability for a grub hatching from an egg which may be laid anywhere in the host larva, and in larvae of varying ages and species.

The known range of host species which *P. persimilis* can successfully use as hosts is interesting. It includes the common cosmopolitan species *D. melanogaster*, *D. simulans*, the less common *D. hydei* and *D. buskii*, and the Australian natives *D. fumida* and *D. nitidithorax*, as well as *Scaptomyza australis*. *Scaptomyza* is a genus closely related to *Drosophila*, but *S. australis* adults are a bit smaller then the *Drosophila* species listed above, and its larvae generally grow in rotting leaf litter. Strangely, there is one common cosmopolitan *Drosophila* species, *D. immigrans*, in which *P. persimilis* readily lays eggs but they never successfully develop. How this species is protected from the parasite is not known. It does not use the melanin-mediated "immune" reaction, since the melanin capsules are not seen in adults whose larvae have been attacked.

The known distribution of *P. persimilis* includes the metropolitan areas of Perth, Adelaide and Melbourne, country areas in Victoria and New South Wales and around Auckland, New Zealand. Related, but as yet not formally described species, are known from the tropical areas of Australia. It is interesting that an insect with such a specialised life style is flexible enough to use the newly-arrived cosmopolitan species as hosts.

There are so many things about *P. persimilis* which we don't yet know, for example, we have no real idea of how this wasp species interacted with it's hosts before Europeans (and cosmopolitan *Drosophila*) came to Australia (actually we do not have much idea

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how and when the cosmopolitan *Drosophila* came here!). Maybe it's distribution was more restricted - say Queensland - and the spread of orchards and introduced hosts allowed it to move south (as *Dacus* - the Queensland Fruit Fly - seems to have done).

One researcher using yeast-baited *Drosophila* traps at a vineyard in Victoria was regularly catching, but ignoring and discarding *P. persimilis* females without realising that they had any relationship with the flies he was studying. This shows how, even for scientists, small, plain parasitic insects are easy to overlook, despite familiarity with the host species. This lack of interest is clearly not justified - their lifestyle presents a fascinating biological story, all the more remarkable because of their small size. How many other small insects do we see each day without giving a thought to how they live their lives and what amazing adaptations they might have evolved?

"Amateur" observation can add significantly to our knowledge of the relationships between insects in Australia, where so many species have yet to be studied by science. Wasps (and some other parasitic insects) are known to use flies, butterflies and moths, beetles and numerous other groups as hosts, and any one host species (including parasitic wasps themselves!) may have more than one possible parasite species. If you get a chance to observe the development of any insect, take a close look at what emerges from the late developmental stages or the pupal case - it might be something very different from what you expect, and you could be the first to document a previously unknown parasitoid/host relationship.

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