SEM Diaries - 35

See how they Run

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Fig. 1: *Larinioides cornutus* (male) - photographed in the lab

A friend from the British Arachnological Society (BAS) phoned me recently with an interesting conundrum. How can it be that some orb web spiders (such as the garden spider *Araneus diadematus)* find it hard to walk on flat surfaces but that at least one, *Larinioides sclopetarius*, has no trouble scuttling away if it falls onto the deck of his canal boat? (*L. sclopetarius* is a species that loves wet places and tends to spin its webs around bridges and lock gates.) Could there be something different about the tarsi between genera or even species within the same genus of the family ARANEIDAE. The tarsus is the outermost joint on each leg of a spider, equivalent to a foot.

Could the difference in ability be, my friend surmised, something to do with the fact that *L. sclopetarius* likes to anchor its web to rigid structures, while most Araneids (including its cousin, *Larinioides cornutus*) support their webs on plants that blow in the wind? This speculation requires a whole study of orb web spiders to determine which are happy running along the ground and which are much less confident. By the time I got round to looking into this the season for collecting live specimens of a variety of orb web spiders and putting

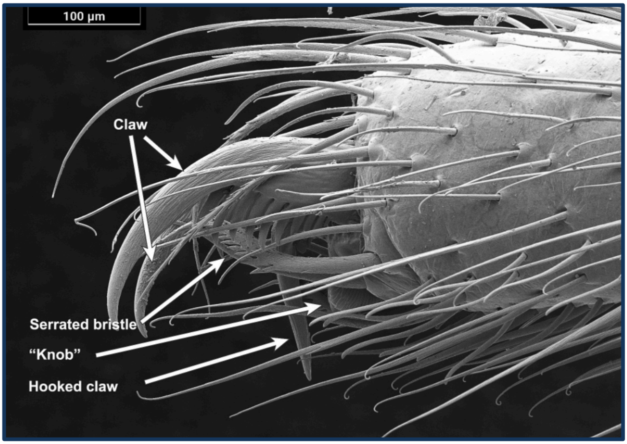

Fig. 2: Tarsus (Left 1) of *Larinioides sclopetarius* (male)

them through a mini-Olympics was past, at least for 2023.

It was, however possible to study the structure of the tarsi of *L. sclopetarius* and *L. cornutus*, and indeed to compare these with other species in different genera using preserved specimens, and drawing on my library of electron micrographs of the tarsi of other genera and families.

Now, the tarsi of web dwellers have three claws. Two of these are curved and have a comb on them, while the third resembles a hook, and is used specifically for grabbing hold of a thread of silk on the web, which it grabs and holds against a serrated bristle on each side of it (Figure 2). The size of a tarsus, even on relatively large spiders such as *Larinioides* spp. is quite small, and just about at the limit of resolution of a conventional stereo microscope, at least if any detail needs to be studied. Furthermore, the tarsi are surrounded by hairs, which makes obtaining the correct orientation of the tarsus in the field of view rather critical. Thus the point of my friend’s telephone call was to determine if I might be able to study the tarsi of the two *Larinioides* species using the SEM and see if there was any material difference between them.

I mentioned earlier that the orientation of the tarsus with respect to the optical path or electron beam is critical if one wants to obtain a good view of the claws between the hairs. Just placing the tarsi on sticky carbon tabs would be very hit and miss. So, several years ago I constructed special stubs that enable me to orientate the tarsus (or any other feature that is not too small) precisely as I need it. I described these in detail in SEM Diaries - 22 (October 2020).

I started by mounting and imaging some tarsi from L. sclopetarius and sent some images to my friend. We discussed these over the phone and the one point about the images not covered in the standard work on spider biology [1] was that it shows a bulbous “knob” below the hooked claw. The two tarsal claws with combs and also the third hook-like claw are all articulated together with this knob, so that perhaps the spider would tilt the claws upwards, at the same time bringing the “knob” round to act as a less fragile foot than the claws.

Even in Figure 2 the knob is somewhat obscured by hairs so I took some more tarsi from the same species and mounted them flat on a sticky carbon tab on a conventional SEM stub. I then attempted to dissect out the hairs to reveal more of the “knob”. The resulting image of the “best” tarsus is shown in Figure 3 (top). This shows that the knob (arrowed) has a ridge either side with a depression between. It also indicated that the outside of the ridge on the visible side is “ribbed”. We were unable to determine whether this is of hard or soft tissue, partly because it is so small as to be difficult to see, let alone prod under a stereo microscope, and partly because preservation in alcohol will have rendered it hard in any event.

The obvious next step was to look at tarsi of *L. cornutus,* and see if they had a similar structure. Figure 3 (bottom) shows a tarsus of *L.* cornutus to the same scale as that of *L. Sclopetariu*s, again with hairs cleared out of the way as best I could. It can be seen that the tarsus of *L. cornutus* has a similar “knob”. This does appear to be more “long and thin” than that of *L. sclopetarius,* but this could possibly be due to the way the tarsus was dissected.

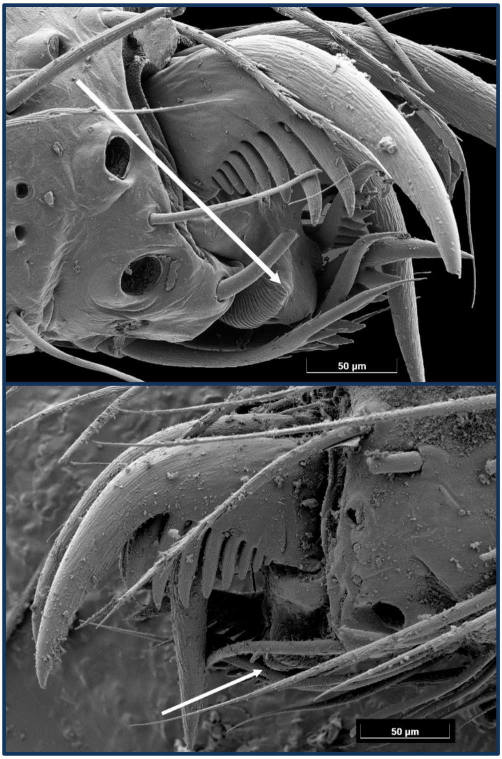

Fig. 3: Dissected tarsi of *L. sclopetarius* (female) - top - and *L. cornutus* (female) - btm - showing the “knob” (arrowed).

Given that, as mentioned above, the tarsal claws, including the “knob” and the hook all appear to be articulated as one rigid object it would seem that the knob is not sufficiently deep as to act as a foot, even with the claws angled upwards as far as they would go.

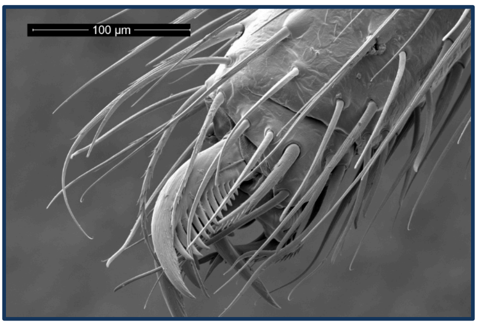

Fig. 4: Tarsal claw of *Zygiella x-notata*

What about other species of orb-web spiders? Figure 4 shows the tarsal claw of *Zygiella x-notata*, a common species that makes its web in the corners of window frames. This shows all the features shown in Figures 2 and 3, including (just visible) the “knob”.

So, how do other spider families, including those that do not live on webs, manage to walk?

One of my favourite common spiders is *Salticus scenicus* (SALTICIDAE). These are the small black and white jumping spiders, with very large forward facing eyes often seen effortlessly clinging to the external walls of houses. A combination of excellent eyesight and quick reactions means that this spider can catch its prey simply by leaping onto it. No web required.

A tarsus of one of these is shown in Figure 5.

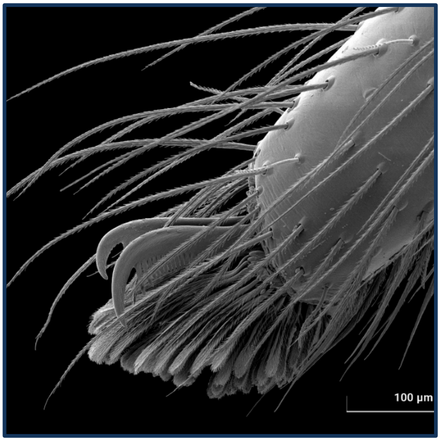

Fig. 5: Tarsus of *Salticus scenicus*, showing the bundle of hairs known as the scopula

As can be seen from the micrograph, the tarsus has two claws similar to that of other genera, but beneath the claws there is a bundle of very fine hairs known as the scopula, from the Latin for a brush. In fact, the hairs visible in that figure are actually groups of even finer hairs, as illustrated in Figure 6. These hairs not only provide cushioning of the tarsus when the spider walks along horizontal surfaces, but also enable the spider to

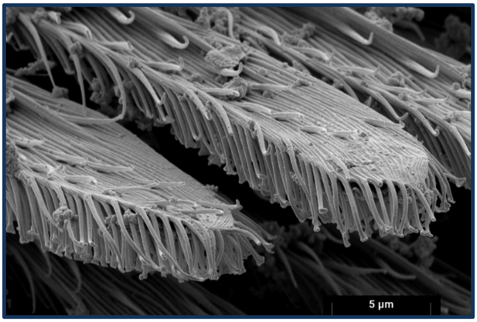

Fig. 6: Illustrating the very fine hairs of the scopula of *Salticus scenicus*.

walk confidently on vertical surfaces or even hang upside down on a ceiling. I shall not attempt to describe the physics behind this action, but it is a similar mechanism to that employed by creatures such as geckos.

On *S. scenicus*, the diameter of the hairs seen hanging down in Figure 6 is of the order of 250 nm, but the tips of these hairs splay out into a bundle of yet finer hairs. Other families have variations in the amount and fineness of hair. For example, the genus *Philodromus* (THOMISIDAE) has fewer scopula hair bundles around the tarsi, but the underside of the tarsus is lined with hairs all the way up to the metatarsus (Figure 7).

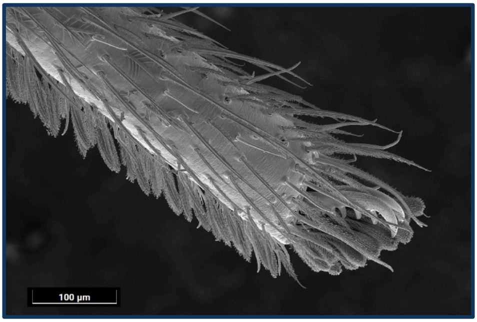

Fig. 7: Illustrating the hairy underside of the tarsus of *Philodromus cespitum*

So, what about other web-dwelling spider families, such as the LINYPHIIDAE. These tiny spiders build three-

Fig. 7: Tarsus of a female *Pocadicnemis juncea* showing similarity to *Larinioides* spp.

dimensional webs and hang from the underside of these. When an insect lands on the top of the web the spider will break its way through the web to catch its prey. A tarsus of such a spider is shown in Figure 7. As can be seen, this bears a good resemblance to that of the orb web spiders previously discussed.

So, where does all this leave the question first posed by my BAS friend, which was how can some orb web spiders run well on flat surfaces while others cannot? I am not convinced by our theory that the "knob" acts as a foot that can space the claws off the surface. I believe it might be possible that although the web dwellers have relatively few hairs on their tarsi, these may have sufficient resilience to take at least some of the spider's weight off the tarsal claws (in addition to performing their main roles as sensory organs). Perhaps the claws are stronger than they might appear and be quite capable of supporting the weight of the spider and providing the main point of contact with a flat surface.

If anyone can shed any light on this question before we manage to carry out a detailed study, we would be glad to hear!

Reference

1. Foelix, R.F. Biology of Spiders, 2nd Edition Oxford University Press 1996