Silk production from tarantula feet questioned

Arising from: S. N. Gorb *et al. Nature* **443,** 407 (2006)

As with all spiders, tarantulas spin silk from specialized structures in the abdomen called spinnerets, which are key features unique to the group. Recently Gorb *et al.*[1] reported that the zebra tarantula *Aphonopelma seemanni* also secretes silk from its feet, which might improve its ability to climb on vertical surfaces. Here we show that when the spinnerets are experimentally sealed, the zebra tarantula cannot secrete silk or similar threads, disagreeing with previous reports by Gorb *et al.*[1]. Additional evidence also disagrees with leg secretion of silk.

We placed four specimens of *A. seemanni* each in separate glass containers with the floor and two vertical walls covered with 20 microscope slides. Tarantulas remained in the container for 14 h, after which the slides were carefully examined. Seventy-two hours later, we sealed the spinnerets of the same individuals with paraffin and repeated the experiments. In the first trials with free spinnerets most slides (24 out of 40 horizontal slides and 16 out of 40 vertical slides) showed silk threads together with dislodged abdominal urticating hairs. None of the slides in the trials with sealed spinnerets showed silk threads; we found only urticating hairs. In both series of trials we observed the spiders walking on vertical surfaces. In addition, we made transverse cuts of *A. seemanni* tarsi and no structures interpretable as silk glands or silk conduits were observed.

Tarantulas entangle silk threads from the spinnerets with their tarsi (Fig. 1). They often use hind legs to entangle silk, but we also observed *A. seemanni* entangling with their other legs. This behaviour might explain the presence of the thread footprints photographed by Gorb *et al.*[1]. Tarantula silk released from spinnerets consists of multiple, roughly parallel silk threads which are better observed when magnified. This pattern could be maintained once the silk line is adhered to the substrate, when combed or stepped by tarsal scopulae. Tarsal structures interpreted as spigots by Gorb *et al.*[1] are very different from the diverse kinds of spigot reported for spiders[2–4]. We found that the structures reported by Gorb *et al.*[1] are very similar in morphology and size to fragments of tarsal thermosensory setae reported for other tarantulas[5]. In insects, a common origin or convergence was proposed for silk spigots and sensory setae[6,7]. The presence of conspicuous, dense scopulae with spatulated setae on the ventral surface of tarsi and metatarsi of all tarantulas seems incompatible with the presence of spinning spigots in a lower layer, because scopula setae might interfere with silk release. Furthermore, it has been explained that in *A. seemanni* the friction with scopula setae is enough to guarantee spider climbing[8].

Figure 1 | The zebra tarantula *Aphonopelma seemanni* entangling a silk thread released from the spinneret with its hind leg, while starting to climb a vertical glass wall. Arrows indicate the silk thread.

During our observations, individuals of *A. seemanni* brushed spinnerets with their hind-leg tarsi while walking and releasing silk threads. The presence of abdominal urticating hairs with silk is indicative of this brushing. We did not find evidence of silk-like secretion through leg structures in tarantulas.

Fernando Pérez-Miles[1], **Alejandra Panzera**[1], **David Ortiz-Villatoro**[1] **& Cintya Perdomo**[1]

[1]Sección Entomología, Facultad de Ciencias, Iguá 4225, 11400 Montevideo, Uruguay.
e-mail: myga@fcien.edu.uy

Received 29 December 2008; accepted 7 August 2009.

1. Gorb, S. N. *et al.* Silk-like secretion from tarantula feet. *Nature* **443,** 407 (2006).
2. Bond, J. E. Setae-spigot homology and silk production in first instar *Antrodiaetus unicolor* spiderlings (Araneae: Antrodiaetidae). *J. Arachnol.* **22,** 19–22 (1994).
3. Coddington, J. A. Spinneret silk spigot morphology: evidence for the monophyly of orbweaving spiders, Cyrtophorinae (Araneae), and the group Theridiidae plus Nesticidae. *J. Arachnol.* **17,** 71–95 (1989).
4. Griswold, C. E., Ramírez, M. E., Coddington, J. A. & Platnick, N. I. Atlas of phylogenetic data for entelegyne spiders. *Proc. Calif. Acad. Sci.* **56,** 1–324 (2005).
5. Raven, R. J. A new tarantula species from northern Australia (Araneae, Theraphosidae). *Zootaxa* **1004,** 15–28 (2005).
6. Ross, E. S. In *The Insects of Australia* 405–409 (Camberra & Melbourne Univ. Press, 1991).
7. Merrit, D. J. The organule concept of insect sense organs: Sensory transduction and organule evolution. *Adv. Insect. Physiol.* **33,** 192–241 (2007).
8. Niederegger, S. & Gorb, S. N. Friction and adhesion in the tarsal and metatarsal scopulae of spiders. *J. Comp. Physiol. A* **192,** 1223–1232 (2006).

doi:10.1038/nature08404

Gorb et al. *reply*

Replying to: F. Pérez-Miles, A. Panzera, D. Ortiz-Villatoro & C. Perdomo *Nature* **461,** doi:10.1038/nature08404 (2009)

The data presented by Pérez-Miles *et al.*[1] call into question the production of tarantula tarsal silk[2], but there remains substantive evidence that would seem to contradict their assertion that tarsal silk is solely due to abdominal silk entangled on to hind legs.

Tarsal silk traces appear consistently from all four pairs of legs, not just the hind pairs that might regularly contact the spinnerets. As can be seen in Fig. 2a of Gorb *et al.*[2], tarsal silk is laid down in parallel tracks, which seems incompatible with it being a secondary deposition of silk combed on to the tarsi. Furthermore, scanning electron microscopy examination of tarsal silk reveals a distinct broad area at the beginning of the fibre that we interpret as an initial fluid (see Fig. 1). Presumably any fluid phase adhesive in abdominal silk would be lost in the transference to the tarsi. Another issue raised by Pérez-Miles *et al.*[1] is that adhesion of the spider to a clean dry surface could

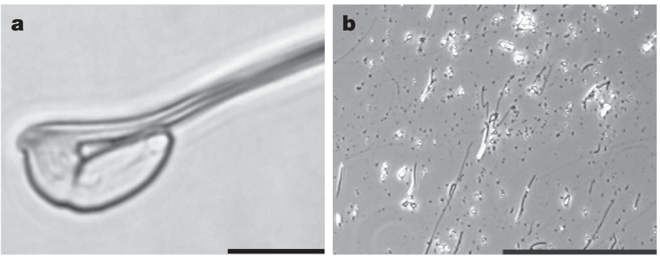

Figure 1 | Leg traces of *Aphonopelma seemanni* (light microscopy). **a**, Starting point of a filamentous trace on coverslip. Scale bar, 1 μm. **b**, Filamentous traces originating from such starting points. Scale bar, 100 μm.

be accomplished entirely with the tarsal setae. The tarsal claws would certainly also suspend the animal from very rough surfaces. The possibility of tarsal silk as a third adhesive mechanism implies that that the biology of tarantulas is such that there is an advantage to redundant systems.

Pérez-Miles *et al.*[1] also propose that the 'spinneret' structures we found are sensory structures, which is intriguing because similarity between the two structures may indicate a common developmental origin. Indeed, it has been suggested that the convergently evolved tarsal silks in web-spinner insects and dance flies arise from derived sensory cells[3]. We remain satisfied that the most plausible explanation for our observations is the existence of tarsal-silk-producing structures scattered within the setae on tarantula tarsi.

Stanislav N. Gorb[1], Senta Niederegger[2], Cheryl Y. Hayashi[3], Adam P. Summers[4], Walter Vötsch[5] & Paul Walther[6]
[1]Zoological Institute of the University of Kiel, Am Botanischen Garten 1–9, D-24098 Kiel, Germany.
sgorb@zoologie.uni-kiel.de
[2]Institut für Rechtsmedizin, Universitätsklinikum Jena, Jena, Germany.
Senta.Niederegger@med.uni-jena.de
[3]University of California, Riverside, California 92521, USA.
[4]Friday Harbor Labs, University of Washington, Washington 98250, USA.
[5]Max Planck Institute for Developmental Biology, 71076 Tübingen, Germany.
[6]Electron Microscopy Department, University of Ulm, 89069 Ulm, Germany.

1. Pérez-Miles, F., Panzera, A., Ortiz-Villatoro, D. & Perdomo, C. Silk production from tarantula feet questioned. *Nature* **461,** 10.1038/nature08404 (2009).
2. Gorb, S. N. *et al.* Silk-like secretion from tarantula feet. *Nature* **443,** 407 (2006).
3. Merritt, D. J. The organule concept of insect sense organs: Sensory transduction and organule evolution. *Adv. Insect Physiol.* **33,** 192–241 (2007).

doi:10.1038/nature08405