Aberystwyth University

Olfactory and tactile cues can guide near-distance location of a refuge by whip spiders (Arachnida, Amblypygi)

Santer, Roger

Published in:
Animal Behaviour

DOI:
10.1016/j.anbehav.2019.10.020

Publication date:
2019

Citation for published version (APA):
Santer, R. (2019). Olfactory and tactile cues can guide near-distance location of a refuge by whip spiders (Arachnida, Amblypygi). *Animal Behaviour*. https://doi.org/10.1016/j.anbehav.2019.10.020

<u>Olfactory *and* tactile cues can guide near-distance location of a refuge by whip spiders (Class Arachnida, Order Amblypygi)</u>

Roger D. Santer

Institute of Biological, Environmental, and Rural Sciences, Aberystwyth University, UK

rds5@aber.ac.uk

Whip spiders (Order Amblypygi) are arachnids with greatly elongated, antenniform first legs that serve a sensory rather than locomotory function (Weygoldt, 2000). In their natural habitat, whip spiders faithfully occupy home refuges, and if experimentally displaced from them, can navigate back (Beck & Görke, 1974; Hebets, Gering, Bingman, & Wiegmann, 2014). If the tips of the antenniform legs (which bear olfactory sensilla) are clipped off or coated in nail polish, experimentally displaced whip spiders fail to return to their refuges (Beck & Görke, 1974; Bingman, Graving, Hebets, & Wiegmann, 2017; Hebets, Aceves-Aparicio, et al., 2014). Thus, it has been proposed that olfactory cues guide the homing behaviour of whip spiders (Beck & Görke, 1974; Bingman et al., 2017; Hebets, Aceves-Aparicio, et al., 2014; Wiegmann et al., 2019). An element of this olfactory hypothesis has now been explicitly tested by Wiegmann et al. (2019), which demonstrates the ability of whip spiders to learn and use olfactory cues to locate a refuge in the laboratory, and that this ability is disrupted after the tips of the antenniform legs are clipped.

In pursuit of this olfactory hypothesis the fact that whip spiders can also use tactile cues to locate a home refuge in the laboratory (Santer & Hebets, 2009), and the possibility that these cues might be important in the natural habitat, has been neglected. The tips of a whip spider's antenniform legs are equipped with a range of sensillum types, including but not limited to, olfactory, contact chemosensory, and mechanosensory hairs (Igelmund, 1987; Santer & Hebets, 2011). In field experiments, clipping off the *ca.* 20 segments at the tips of the antenniform legs has been interpreted as a primarily olfactory manipulation because it removes all olfactory sensilla whilst leaving some of the other types present elsewhere (Bingman et al., 2017; Hebets, Aceves-Aparicio, et al., 2014). Although the possibility of disruption to sensation in other modalities has been acknowledged (Hebets, Aceves-Aparicio, et al., 2014), this interpretation overlooks the special importance of tactile sensory structures at the antenniform leg tips. The antenniform legs of whip spiders are equipped with an array of at least seven giant sensory afferents whose cell bodies are found within the distal segments of the antenniform leg (Igelmund & Wendler, 1991a, 1991b; Santer & Hebets, 2011; Spence & Hebets, 2006). Four of these giant neurons (GNs) have characterised mechanosensory functions and receive inputs from known fields of mechanosensory sensilla at the antenniform leg tip. GN1 and GN2 each receive inputs from bristle sensilla in two overlapping fields that each includes some of the most distal 20 segments of the antenniform leg (Igelmund & Wendler, 1991a, 1991b; Spence & Hebets, 2006). GN6 and GN7 are excited via a slit sensillum responding to movement at the articulation between the 21^{st} and 22^{nd} segments of the antenniform leg tip (Igelmund & Wendler, 1991a; Spence & Hebets, 2006). Furthermore, high-speed cinematography reveals that when examining surfaces, whip spiders tap, press, and scrape the tips of their antenniform legs against the surface in a way that might allow the spike trains of these four giant neurons to encode tactile information like shape and texture (Santer & Hebets, 2009, 2011). There can be no doubt that clipping off or covering *ca.* 20 segments at the tips of the antenniform legs would disrupt tactile sensory input to these giant neurons, and the former manipulation might damage or destroy the giant neurons themselves. Thus, the disruption of tactile sensation might also contribute to the inability of whip spiders to locate their home refuge after such an experimental manipulation. Most importantly, laboratory experiments *have already shown* that whip spiders have the ability to learn texture cues and associate them with a refuge (Santer & Hebets, 2009).

The motivation of this note is not to refute the findings of Wiegmann et al. (2019): that work demonstrates that olfactory cues can be used by whip spiders to locate a refuge, and that clipping off the tips of the antenniform legs disrupts that ability. However, this note does emphasise that there is also physiological and behavioural evidence supporting the use of tactile cues in such near-distance location of a refuge. In another extraordinary animal navigator, the desert ant *Cataglyphis*, experiments show that visual (Collett, Dillmann, Giger, & Wehner, 1992), olfactory (Steck, Hansson, & Knaden, 2009), and tactile cues (Seidl & Wehner, 2006), can all contribute to the accurate location of the nest. Wiegmann and colleagues anticipate that whip spider navigation also relies on multimodal sensory cues (Wiegmann, Hebets, Gronenberg, Graving, & Bingman, 2016), and in that multimodal context the tactile sensing abilities of these fascinating animals should not be overlooked (c.f. Santer & Hebets, 2009).

Beck, L., & Görke, K. (1974). Tagesperiodik, Revierverhalten und Beutefang der Geißelspinne *Admetus pumilio* C.L. Koch im Freiland. *Z Tierpsychol, 35*, 173-186.

Bingman, V. P., Graving, J. M., Hebets, E. A., & Wiegmann, D. D. (2017). Importance of the antenniform legs, but not vision, for homing by the neotropical whip spider *Paraphrynus laevifrons*. *J. Exp. Biol., 220*, 885-890.

Collett, T. S., Dillmann, E., Giger, A., & Wehner, R. (1992). Visual landmarks and route following in desert ants. *J. Comp. Physiol. A, 170*, 435-442.

Hebets, E. A., Aceves-Aparicio, A., Aguilar-Argüello, S., Bingman, V. P., Escalante, I., Gering, E. J., . . . Stafstrom, J. A. (2014). Multimodal sensory reliance in the nocturnal homing of the amblypygid *Phrynus pseudoparvulus* (Class Arachnida, Order Amblypygi)? *Behav. Processes, 108*, 123-130.

Hebets, E. A., Gering, E. J., Bingman, V. P., & Wiegmann, D. D. (2014). Nocturnal homing in the tropical amblypygid *Phrynus pseudoparvulus* (Class Arachnida, Order Amblypygi). *Anim. Cogn., 17*, 1013-1018.

Igelmund, P. (1987). Morphology, sense organs and regeneration of the forelegs (whips) of the whip spider *Heterophrynus elaphus* (Arachnida, Amblypygi). *J. Morphol., 193*, 75-89.

Igelmund, P., & Wendler, G. (1991a). The giant fiber system in the forelegs (whips) of the whip spider *Heterophrynus elaphus* Pocock (Arachnida: Amblypygi). *J. Comp. Physiol. A, 168*, 63-73.

Igelmund, P., & Wendler, G. (1991b). Morphology and physiology of peripheral giant interneurons in the forelegs (whips) of the whip spider *Heterophrynus elaphus* Pocock (Arachnida: Amblypygi). *J. Comp. Physiol. A, 168*, 75-83.

Santer, R. D., & Hebets, E. A. (2009). Tactile learning by a whip spider, *Phrynus marginemaculatus* C.L. Koch (Arachnida, Amblypygi). *J. Comp. Physiol. A, 195*, 393-399.

Santer, R. D., & Hebets, E. A. (2011). Sensory and behavioural biology of whip spiders. *Adv. Insect Physiol., 41*, 1-64.

Seidl, T., & Wehner, R. (2006). Visual and tactile learning of ground structures in desert ants. *J. Exp. Biol., 209*, 3336-3344.

Spence, A. J., & Hebets, E. A. (2006). Anatomy and physiology of giant neurons in the antenniform leg of the amblypygid *Phrynus marginemaculatus*. *J. Arachnol., 34*, 566-577.

Steck, K., Hansson, B. S., & Knaden, M. (2009). Smells like home: Desert ants, *Cataglyphis fortis*, use olfactory landmarks to pinpoint the nest. *Front. Zool., 6*, 5.

Weygoldt, P. (2000). *Whip spiders (Chelicerata: Amblypygi). Their biology, morphology and systematics*. Stenstrup: Apollo Books.

Wiegmann, D. D., Hebets, E. A., Gronenberg, W., Graving, J. M., & Bingman, V. P. (2016). Amblypygids: model organisms for the study of arthropod navigation mechanisms in complex environments? *Front. Behav. Neurosci., 10*, 47.

Wiegmann, D. D., Moore, C. H., Flesher, N. R., Harper, E. D., Keto, K. R., Hebets, E. A., & Bingman, V. P. (2019). Nocturnal navigation by whip spiders: antenniform legs mediate near-distance olfactory localization of a shelter. *Anim. Behav., 149*, 45-54.