THE ARIZONA SPIDER WASP *Notocyphus dorsalis arizonicus* (Hymenoptera, Pompilidae): NEW LARVAL BEHAVIOR

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ABSTRACT

This is an additional account of parasitism by the wasp *Notocyphus dorsalis arizonicus* Townes (Hymenoptera, Pompilidae) on a juvenile host of the Theraphosid *Aphonopelma chalcodes* Chamberlin. This account compares observations and findings by Byrne (2016, Arizona-Sonora Desert Museum) with those of Minch (1979, Arizona State University) and Simons (1989, Arizona State University), and elucidates previously unreported larval behavioral and physical observations that warrant future investigation. These larval behaviors are the focus of this work, and are discussed at length.

NATURAL HISTORY SYNOPSIS, ADULT

Notocyphus dorsalis arizonicus is a diurnal, sexually dimorphic Pompilid wasp in the subfamily Notocyphinae, of which only two phenotypes are described in the United States (Cresson, 1872; Townes, 1957). These nectar-feeding wasps utilize juvenile Theraphosids as reproductive hosts, depositing a single ovum at the junction of the thoracic-abdominal dorsum. The average length of the juvenile Theraphosids was calculated at 22 mm utilizing the specimen observed by this author, in addition to the specimen measurements provided in Minch (1979) and Simons (1989). While initial contact and interactive behaviors between *Notocyphus dorsalis arizonicus* and Theraphosids have not yet been reported, it is theorized that ovum deposition takes place upon the conscious, otherwise unaltered spider. The egg is deposited at a dorsal position that the Theraphosid cannot easily reach or defend. The juvenile Theraphosids described by Minch, Simons and this author were all discovered wandering diurnally, with no apparent burrow association. It is yet unknown whether adult *Notocyphus* seek out Theraphosids within their burrows, or if they strictly capitalize on displaced or wandering individuals. It is plausible that these nocturnal Theraphosids become diurnally displaced from their burrows via the well-known 'eviction behavior' that other diurnal Pompilid wasps employ, but this is currently unknown.

NATURAL HISTORY SYNOPSIS, LARVA

The specifics of larval development, namely growth rate and its corresponding timeline were so similar to Minch (1979) and Simons (1989), they will not be outlined here. Instead, the focus will highlight previously undescribed behaviors of the developing larva. Upon hatching, the larval wasp maintained an immobile position at the dorsal cephalothorax/abdominal junction as it withdrew liquid nutrition from the host. The host spider continued normal feeding behavior and

activity. At approximately 3.5 weeks after the *Notocyphus* larva hatched, the Theraphosid collapsed and expired. The exact mechanism of action for the spider's death is unknown. Just prior to death, the moribund spider spun an elevated sheet of web (hereafter referred to as the web hammock) approximately 1 cm above the enclosure substrate. The larva then changed its position in relation to the spider (from transverse across the host's body to perpendicular and vertical) and utilized the web hammock to physically support its own body. It then cradled and supported the Theraphosid body with its own, creating a ventral feeding surface to support the remaining amorphous mass of internal organs. The feeding strategy then changed from imbibing fluid to chewing and devouring the host's remains. Once sufficient nutrition was ingested, the larva grinded the remaining spider parts (i.e., legs and chelicerae), and retained this loose pile of integument within the ventral curvature of its body. The larva altered its position a second time by rotating to face supportive structure in its immediate proximity. Coarse, pale filaments were generated by the larva, and attached as supportive pre-pupation anchor lines. The cradled Theraphosid integument on the larva's ventral surface was distributed and attached along these supportive lines, altering the appearance of the filaments from translucently pale to the brown color of the Theraphosid integument.

NATURAL HISTORY SYNOPSIS, PUPATION

While still atop the Theraphosid web hammock, the larva changed position a third and final time, and spun a pale, filamentous cocoon that was elevated from but parallel to the enclosure substrate. Theraphosid integument was distributed by the larva throughout the structure, affecting a color change, crypsis and probable urticating protection. Pupation occurred within the opaque cocoon. The entire structure was supported by the Theraphosid web hammock approximately 1 cm above the substrate.

NATURAL HISTORY SYNOPSIS, CAPTIVE-REARED ADULT

The temperature of the insectarium at the Arizona-Sonora Desert Museum was 25° C (77° F), with variable humidity of 27-33%. Photoperiod was controlled, but a sky-light was present overhead. A 4 mm exit hole was created by the emerging wasp at one end of the cocoon pre-eclosion. Eclosure occurred 71 days post pupation. The resulting female *Notocyphus* measured 21 mm (greatest length, excluding antennae). Flight was very rapid and difficult to follow with the eye. Like many wasp species, it was highly alert and aware of even slight movement. No defensive behavior was observed while interacting with the department keepers. The *Notocyphus* female survived for 15 days, and fed readily on cut grapes, apples and oranges. The specimen is mounted, labeled and resides in the Arizona-Sonora Desert Museum arthropod collection for reference. Photographic and video documentation of the ovum, larva and imago were collected for reference and study.

DISCUSSION: LARVAL BEHAVIORS

Previous insights regarding the larval behaviors of *Notocyphus dorsalis arizonicus* are limited, as these studies were focused on growth measurement, timeline and environmental aspects of *Notocyphus* natural history. The following newly-observed and described behaviors are postulated:

Repositioning: The *Notocyphus* larva was immobile for the first 3 to 3.5 weeks of the 4-week larval state, but changed position three times pre-pupation. The first time, the larva detached its sucking mouth parts from the host, and assumed a vertical position which supported the host's body with its own. Feeding strategy then changed to chewing and devouring of the amorphous remains. The second repositioning was a turn of about 180° (while maintaining a vertical orientation) in order to spin and attach supportive, filamentous anchors, but the degree of this movement will likely vary according to the available environmental supportive structures within the larva's immediate proximity. This second repositioning sequence also includes the distribution of dry Theraphosid integument along the pale, supportive strands. The third and final change of position was a shift from a vertical position to a horizontal orientation followed by the creation of a pupal cocoon. The filamentous strands comprising the cocoon are pale and translucent, but a brown coloration is added as the ground-up spider integument is incorporated into the cocoon matrix.

The 'Web Hammock': Minch (1979) describes a sheet of web spun by his Theraphosid prior to death. Minch also references Williams (1928). Williams was studying the behavior of a previously named species, *Notocyphus tyrannicus* (Smith, 1855), an Ecuadorian species that also parasitizes the live, otherwise unaltered Theraphosid. This tropical spider was also observed spinning a sheet of web just prior to death. Simons (1989) does not mention a pre-death web associated with his encounter. The web hammock generated by the Theraphosid studied at the Arizona-Sonora Desert Museum appeared to directly serve the needs of the *Notocyphus* larva, but was not apparently useful for the Theraphosid. The timing of the construction of this sheet of web is reported by Minch (1979) and Williams (1928) as being spun just prior to death. These observations are commensurate with this author's findings. The web sheet measured approximately 3 cm by 4 cm, and was elevated about 1 cm above the substrate. As the larva reoriented its position three times serving as many purposes, this web sheet seems to be a crucial element of support, particularly advantageous with a vertically oriented and position-shifting larva. A second survival advantage of the elevated web hammock might be avoidance of detection by other arthropods (i.e., ants). A third advantage could be stated as prevention of rot and breakdown of the pupa by microorganisms. The pupal stage is likely reached during the summer rainy season, so maintaining a dry pupa atop an elevated web hammock could prove beneficial in this way. Additionally, the pupa, encased in a cocoon festooned with urticating hairs, may be afforded some protection from rodent predation. Finally, parasitoid behavioral influence over a host is a previously explored concept (Thomas, et al., 2002). It is plausible that *Notocyphus* larvae may possess the ability to biochemically influence their host spiders, causing the Theraphosids to spin a supportive web structure just prior to death, and possibly inducing the death of the host as well.

DISCUSSION: TARANTULA AND WASP INTERACTION

While it is within the realm of possibility that adult *Notocyphus dorsalis arizonicus* females exclusively seek out exposed, displaced or wandering juvenile Theraphosids, this seems unlikely. It is uncommon to find juvenile *Aphonopelma chalcodes* away from their burrows (Gertsch, 1949 *in* Minch, 1979). *Notocyphus dorsalis arizonicus* is known to be diurnal and active from mid-June to late August (Townes, 1957). By the author's personal observation, *Aphonopelma chalcodes* is both crepuscularly and nocturnally active. From a reproductive standpoint, the long-term survival of a diurnal wasp species relying on the uncommon, diurnal wanderings of a largely nocturnal spider seems evolutionarily contrary. Additional observation is needed to elucidate whether adult *Notocyphus dorsalis arizonicus* seek out Theraphosid burrows, or if this behavior is altogether absent.

CLOSING COMMENTS

Notocyphus dorsalis arizonicus is one of approximately 38 known species and subspecies in the primarily tropical subfamily Notocyphinae. The opportunity to observe and record the larval behavior involving a wandering host spider is unique, since many of these host and parasitoid interactions are nearly unobservable underground. As awareness of this group of wasps gains momentum in an age where photographic and video recording access is prolific, new observations and studies will undoubtedly hasten the advancement of scientific understanding of this Pompilid subfamily.

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