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Nesting behavior of the spider wasp
Calopompilus pyrrhomelas (Walker)
(Hymenoptera: Pompilidae)

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Nesting behavior of the spider wasp
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Abstract. The nesting behavior of the spider wasp *Calopompilus pyrrhomelas* (Hymenoptera: Pompilidae: Pepsini) is described for the first time based on independent observations and photographic series from Oakland, Alameda County, CA; Denio, Humboldt County, NV; and Tamalpais-Homestead Valley, Marin County, CA, respectively. The three wasps captured, immobilized, and provisioned the spider's own burrows with *Calisoga longitarsis* (Simon) (Nemesiidae) and *Antrodiaetus montanus* (Chamberlin and Ivie) (Antrodiaetidae).

Key words. Antrodiaetidae, *Antrodiaetus montanus*, Nemesiidae, *Calisoga longitarsis*, California false tarantula.

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Introduction

The genus *Calopompilus* Ashmead is one of the “most primitive” genera in the family Pompilidae as evidenced by its broad hind wings and anal lobe, lack of specialization in wing venation, stout “scolioid” body structure, and full complement of leg bristles (Townes 1957). Short stout legs and antenna segments, bidentate mandibles, short and wide clypeus, long and flat pronotum, and tarsal claws with an erect tooth are presumed *Calopompilus* adaptations for hunting trapdoor spiders and related Mygalomorphae species (Kurczewski and West 2022). Spider wasps that capture and provision their nests with trapdoor spiders and related mygalomorphs have been scarcely studied compared to pompilids that prey on araneomorph spiders (Evans and Yoshimoto 1962; Kurczewski and Kurczewski 1968; Krombein 1979; Wasbauer and Kimsey 1985; Kurczewski and Edwards 2012; Kurczewski et al. 2017, 2020, 2022). There is host mygalomorph spider association data for only two of the eight U.S. *Calopompilus* species, *C. heiligbrodtii* (Cresson) and *C. pyrrhomelas* (Walker) (Kurczewski et al. 2020, 2022), despite some of the species being large and attractive. This scarcity of information is probably linked to *Calopompilus* species capturing the host spider near its burrow and using the spider's burrow as a nest (Kurczewski and West 2022).

The only two host records for *C. heiligbrodtii*, based on iNaturalist.org online photographs, are *Eucteniza relata* (O. P.-Cambridge) (Euctenizidae), adult male [det. R. Godwin]; and *Myrmekiaphila comstocki* Bishop and Crosby, adult or subadult female (Euctenizidae) [det. R. Godwin] (Kurczewski et al. 2020). *Calopompilus pyrrhomelas*, a much more common species than *C. heiligbrodtii*, has been collected or photographed with host mygalomorph spiders several times: *Antrodiaetus pacificus* Simon (Antrodiaetidae) (Krombein 1958; Kurczewski et al. 2020); *A. pugnax* (Chamberlin) (Coyle 1971); *Atypoides riversi* O. P.-Cambridge (Antrodiaetidae)

(Kurczewski and West 2022); and *Calisoga longitarsis* (Nemesiidae) (Kurczewski et al. 2020, 2022; Kurczewski and West 2022). None of these observations or photographs are detailed enough to show that *Calopompilus pyrromelas* used the spider's burrow as a nest, except for Coyle (1971). Coyle (1971) reared *C. pyrromelas* from a burrow of *Antrodiaetus pugnax* in Oregon (Kurczewski and West 2022). Recently, Blackwell (2022), Hedin (2022), and Wang (2022) not only confirmed that *Calopompilus pyrromelas* appropriated the burrows of *Calisoga longitarsis* and *Antrodiaetus montanus* for nests, but they independently photographed nearly the entire nesting sequence to support their observations. Theirs are the first observations of the nesting biology of *C. pyrromelas* that detail the sequence of behavioral components from the wasp finding the spider in its burrow to immobilizing it on the ground surface and pulling it inside its burrow to provide food for the future wasp larva.

Materials and Methods

Rick West noticed several photographs on iNaturalist.org of a large spider wasp with bright orange wings capturing a California false tarantula (*Calisoga* Chamberlin). Frank Kurczewski identified the spider wasp as being *Calopompilus pyrromelas*, a common species in the northwestern U.S. and British Columbia. West initially identified the spider as being *Calisoga longitarsis* (Nemesiidae). Marshal Hedin confirmed the identity of the spider. West emailed Kerry Blackwell, who had taken the photographs of the wasp and spider interaction and placed them on iNaturalist.org. Blackwell not only replied with information about the wasp and spider encounter, but she also sent additional photographs that filled in gaps in the chain of behavioral events (Fig. 1–4). A few weeks later, Marshal Hedin, who reviewed the initial manuscript, photographed a similar sequence of nesting activities by *C. pyrromelas* at a different locality and involving a different host spider, *Antrodiaetus montanus* (Antrodiaetidae) (Fig. 5–12). A week after that, Wang (2022) photographed and videographed an almost identical sequence of activities during which *Calopompilus pyrromelas* captured and entombed *Calisoga longitarsis* in its own burrow. Kurczewski wrote the manuscript in which he interpreted and described the sequence of interactions between wasp and spider based on Blackwell's, Hedin's, and Wang's independent observations and photographs. Hedin, Kurczewski, and West selected the photographs to accompany the text.

Results

On 14 July 2022 in the late afternoon (1717–1738 PDT) in Oakland, Alameda County, CA, Blackwell (2022) observed and photographed a female of *Calopompilus pyrromelas* attacking and capturing a *Calisoga longitarsis* (Nemesiidae) [det. R. West, M. Hedin], adult or subadult female (Fig. 1–4). The entire sequence of hunting, host capture, and nesting took ~21 minutes. The soil on which this interaction occurred was hard-packed and crumbly with sparse grasses, dried surface crevices, depressions, and holes. A series of nine photographs shows the wasp near the spider's open burrow, capture of the California false tarantula, immobilized spider lying dorsal side upward beside its burrow, and the spider wasp standing nearby. The wasp, searching on the ground, located the spider's burrow with the spider inside. Enticing the spider to its burrow entrance, she extracted it from its retreat, using her mandibles and legs. The spider ran across the ground and tried to hide in a depression in the soil. The wasp quickly found the spider and the two grappled for several seconds during which the spider was stung by the wasp one or more times in the underside of its cephalothorax near the leg bases. The wasp walked away briefly, groomed, and rested as the spider acquiesced from the effect of the venom. She returned to the prey, grasped the immobilized spider with her mandibles, probably by a leg, and pulled it backwards across the ground toward its burrow. The wasp positioned the spider with its abdomen next to the burrow entrance for ready entry. She briefly walked away to groom and rest before returning to the spider. She partly entered the opening, then grasped the spinnerets of the spider with her mandibles and pulled it slowly inside. The spider gradually disappeared, its face being the last body part to be seen. The wasp likely dragged the spider to the bottom of its burrow and laid an egg on its abdomen. She then probably scraped soil from the sides of the burrow over the entombed host before leaving.

On 10 August 2022 between 1130 and 1200 (PDT) just SE of Denio, Humboldt County, NV in mature great basin sage (*Artemisia tridentata* Nutt.) habitat with sandy soils, Hedin (2022) observed and photographed a



Figures 1–4. *Calopompilus pyrrhomelas* (Pompilidae) and *Calisoga longitarsis* (Nemesiidae). Photographs © Kerry Blackwell. 1) Wasp extracted host spider from its open burrow and is searching for it on the ground surface. 2) Wasp caught the escaped spider, stung and paralyzed it, and is examining it as it lies ventral side upward on the ground. 3) Wasp dragged the immobilized spider next to its burrow entrance and is repositioning it with its abdomen beside the opening for ready entry. 4) Wasp walked away from the repositioned spider to groom and rest before returning to pull it inside and down its burrow.



Figures 5–12. *Calopompilus pyrromelas* (Pompilidae) and *Antrodiaetus montanus* (Antrodiaetidae). Photographs © Marshal Hedin. **5)** Immobilized host spider, as initially found, about one meter from its burrow entrance. **6)** Wasp dragging spider backwards across sand some distance from its burrow entrance, grasping the end of its right foreleg with her mandibles. **7)** Wasp entering and exiting the spider's open burrow—a form of reconnaissance. **8)** Wasp dragging spider backwards near its open burrow, grasping its spinnerets with her mandibles. **9)** Wasp backing into entrance with spider in tow, retaining grasp of its spinnerets with her mandibles. **10)** Spider gradually disappearing as it is being pulled down the burrow by wasp. **11)** Partly closed collapsible collar door with wasp and spider inside burrow. **12)** Fully closed collapsible collar door with wasp and spider inside burrow.

Calopompilus pyrrhomelas female deposit an immobilized *Antrodiaetus montanus* (Chamberlin and Ivie) (Antrodiaetidae), adult female, in the host spider's burrow (Fig. 5–12). The spider was first found, dorsal side upward, lying motionless and evidently paralyzed from the wasp's stinging under a sage. The wasp was seen searching near the spider, then finding it. The spider's open burrow was located about one meter from the motionless spider in a small sand clearing. It is unclear if the spider had exited its burrow naturally and was wandering or if the wasp had removed or frightened it from its burrow. Female *Antrodiaetus* Ausserer are not known to wander from their burrow entrances (Coyle 1971). Minutes later the wasp proceeded to drag the spider backwards toward its open burrow, ventral side upward, by grasping the end of its right hind leg with her mandibles. Periodically, she released the spider on the sand, returned to the burrow, entered, and exited—probably a form of reconnaissance. Upon returning to the spider, she examined it with her antennae and mouthparts. As the wasp with spider in tow, ventral side upward, got closer to the burrow entrance she grasped it by its spinnerets with her mandibles in preparation for entering the opening in this manner. She released the spider on the sand, entered the spider's burrow, then exited 15–30 seconds later to relocate the spider two or three times in succession. The wasp gradually dragged the spider into the burrow, grasping its spinnerets with her mandibles as the collapsible collar door closed naturally behind them. The closed burrow entrance was observed for five minutes, but the wasp had not exited the burrow. She was probably positioning the immobilized spider at the bottom of the burrow, ovipositing on its abdomen, and sealing off that portion of the burrow with soil scraped from the burrow walls.

On 17 August 2022 at 1805 (PDT) at Tamalpais-Homestead Valley, Marin County, CA on bare soil with sparse vegetation, Wang (2022) observed and photographed a *Calopompilus pyrrhomelas* female extract, chase, capture, transport, and deposit an immobilized gravid *Calisoga longitarsis* in its own burrow. The wasp chased the California false tarantula from its entrance and across open ground, caught it, grappled with it, during which the spider was stung one or more times in the underside of its cephalothorax. After the spider acquiesced from the effect of the venom, the wasp grasped the immobilized spider by its second right coxa-trochanter joint and dragged it backwards very slowly and haltingly, ventral side upward, across the ground toward the open burrow, less than a meter away. She paused, released the spider, and cleaned her antennae twice with her foreleg antennal cleaner. She continued to struggle in dragging the heavy spider, switching her mandibular grasp to the left forecoxa-trochanter joint, third right coxa-trochanter joint, and, later, right forecoxa-trochanter joint. The wasp eventually pulled the spider to the edge of its entrance, released it, walked away for several seconds, paused, returned, entered the burrow, and exited headfirst. She re-entered the burrow and, from inside, grasped the metatarsus of the spider's left hindleg and, with it in tow, backed downward. Inside the burrow, she probably switched her mandibular grasp to the spider's spinnerets as she pulled it to the bottom of the burrow where she would position it, lay an egg on its abdomen, and scrape soil over it, sealing it in place.

Discussion

Coyle (1971) reared a "*Dinocnemis*," a synonym of *Calopompilus* and undoubtedly *C. pyrrhomelas*, the only species of *Calopompilus* in Oregon, from an *Antrodiaetus pugnax* adult female burrow in Benton County, OR but furnished no information on the behavioral sequence of finding, capturing, immobilizing, stocking, and ovipositing on the host spider. Blackwell's (2022), Hedin's (2022), and Wang's (2022) photographs and observations provide nearly the complete behavioral sequence that supports *Calopompilus pyrrhomelas* using the host spiders' burrow as a nest for rearing its larva. A key facet of the hunt and capture sequence by the wasp was to entice the spider to the open entrance and, using her mandibles and legs, extract it or frighten it from its burrow. Free from the confines of the burrow and on the ground surface, the spider wasp has the advantage of strong capture instinct, rapidity of movements, and maneuverability to subdue and immobilize the spider (Kurczewski and West 2022). Capture of the spider outside of its burrow counters the century-old belief that the wasp enters and descends the spider's burrow to attack its host underground (Kurczewski and West 2022). Blackwell's (2022), Hedin's (2022), and Wang's (2022) photographs confirm prior observations of *C. pyrrhomelas* during which the spider wasp attacked and captured the host spider on the ground surface near its burrow (Kurczewski et al. 2020, 2022). One such observation detailed the wasp transporting the immobilized spider backwards on the ground, grasping a hind leg with her mandibles, then pulling it into a hole, probably its own burrow (Kurczewski et al.

2022). Another observation showed the wasp dragging the spider backwards, grasping its right foreleg with the mandibles, the spider missing its abdomen and right hindleg (Kurczewski et al. 2020, 2022)! Two online photographs of the wasp stinging the spider showed the spider in a dorsal side upward position on the ground. In the first example the wasp straddled the spider obliquely, bent the end of her abdomen under its cephalothorax and inserted the sting (Kurczewski et al. 2020). In the other example the wasp straddled the spider perpendicularly, bent its abdomen underneath, and attempted to sting it in the underside of its cephalothorax near a leg base while grasping its second left leg with her mandibles (Kurczewski et al. 2022).

Coyle (1971) described burrows of *Antrodiaetus montanus* females as relatively deep (31–46 cm), with silk more conspicuous in the upper part of the burrow, and with flexible silken collar entrances about 1.4 cm in diameter. Coyle (1971) did not include records of predators for *A. montanus*, but pompilids are known to attack other western species in this genus (Kurczewski et al. 2020), including *A. pugnax* (Coyle 1971). *Antrodiaetus montanus* is most common in mid- to high-elevation Great Basin Desert habitats of the western US.

The genus *Antrodiaetus* falls within the larger mygalomorph clade Atypoidea, while *Calisoga* is well nested within the larger clade Avicularioidea (Opatova et al. 2020). These clades share a most recent common ancestor estimated to have existed over 300 million years ago (Opatova et al. 2020). The fact that *Calopompilus pyrrhomelas* preys upon members of these divergent lineages suggests a relatively broad host range for this wasp, spanning the ancient root of all mygalomorph spiders.

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