

Behavioural observations of the host-brood parasite relationship of *Euchroeus purpuratus* (FABRICIUS, 1787) (Hymenoptera: Chrysididae)

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Abstract

The host-brood parasite relationship of the cuckoo wasp *Euchroeus purpuratus* (FABRICIUS, 1787) (Chrysididae) to the hairy sand wasp, *Podalonia hirsuta* (SCOPOLI, 1763) (Sphecidae), as assumed in old literature, has been doubted in the past because the cuckoo wasp is extremely rare in contrast to its host. The first author observed and photographically documented four females of *E. purpuratus* following a caterpillar-bearing female of *P. hirsuta* at close range. This observation largely corroborates previous observations by Arnulf Molitor in 1934, also in Austria.

Key words. *Euchroeus purpuratus*, *Podalonia hirsuta*, host-brood parasite relationship, observation, Austria.

Zusammenfassung

Die Wirtsbeziehung der Goldwespe *Euchroeus purpuratus* (FABRICIUS, 1787) (Chrysididae) zur Kurzstiel-Sandwespe, *Podalonia hirsuta* (SCOPOLI, 1763) (Sphecidae), wie in der alten Literatur vermutet, wurde in der Vergangenheit immer wieder angezweifelt, da die Goldwespe im Gegensatz zu ihrem Wirt extrem selten ist. Der Erstautor konnte *E. purpuratus*-Weibchen beobachten und fotografisch dokumentieren, die eine raupeneintragende Kurzstielsandwespe *Podalonia hirsuta* in geringem Abstand verfolgten. Dies stützt Beobachtungen von Arnulf Molitor im Jahr 1934, ebenfalls aus Österreich.

Introduction

Apart from the flower-visiting species, observations of cuckoo wasps in the wild are generally rare, as these animals move quickly and seldom stay in one place for more than a few seconds. If the opportunity arises to observe a particular cuckoo wasp in the wild for an extended period of time, it should be considered a stroke of luck. And if this species is a rare one such as *Euchroeus purpuratus* (FABRICIUS, 1787), which shows a particularly strange behaviour, as described below, this is certainly a reason to share these observations with the community. Perhaps a more complete picture will emerge from these pieces of the puzzle, helping to clarify the biology of this beautiful and rare cuckoo wasp.

All cuckoo wasps develop as parasitoids or cleptoparasites (PAULI et al. 2018). In most species, the female sneaks into the host nest and lays an egg, from which a larva hatches. The larva is exclusively carnivorous and consumes the host or its larval provisions. Most cuckoo wasps are highly specialized in their host choice (e.g., SAURE 1998, WIESBAUER et al. 2020):

Depending on the species, they parasitize various aculeate hymenopterans (e.g., Vespidae, Sphecidae, Crabronidae, Pompilidae, and Megachilidae) or – in rare cases – even sawflies, walking sticks, and moths. However, not all cuckoo wasps seek out the host nest or enter it: There are also species that secretly lay their eggs in the host's larval provisions, thereby making the host female unknowingly carry the "Trojan horse" to its nest (e.g., WINTERHAGEN 2015).

Only a few observations regarding the biology of *Euchroeus purpuratus* exist in the literature. The first one was made by Arnulf Molitor in 1934 (MOLITOR 1935). He describes two cuckoo wasp females following a *Podalonia* [as *Psammophila*] *hirsuta* (SCOPOLI, 1763) hunting a caterpillar. He considered the behaviour to be reminiscent of the behaviour of parasitoid flies. In his report he states: "*Euchroeus* always kept the same distance – a few cm – to *Psammophila*. As soon as she rested (after depositing her prey), *Euchroeus* took their spots on the floor of the sand pit (near Guntramsdorf) where this all took place. They positioned themselves behind *Psammophila*, then flanking her, ready to fly off as soon as she took off again and then continued to follow her slowly." [translated from original German: „Stets hielten die *Euchroeus* annähernd gleichen Abstand – ein paar cm – von der *Psam.*; rastete diese (nach Ablegen ihrer Beute), so nahmen auch die Goldwespen auf dem Boden der Sandgrube (bei Guntramsdorf), wo sich der Vorgang abspielte, ihre Plätze ein – bald beide hinter der *Psam.*, bald sie in die Mitte nehmend – um sofort wieder aufzufliegen und jene langsam fliegend zu verfolgen, sobald sie sich wiederum auf den Weg machte.“]

The host-brood parasite relationship with *Podalonia* has been put into question in the past since the host is very common (BLÖSCH 2000) while the cuckoo wasp *Euchroeus purpuratus* is very rare (LINSENMAIER 1968). On September 9th, 2021, the first author was able to make behavioural observations of *E. purpuratus* that support Molitor's hypothesis.

Observations

The study area is a slope with Neogene fine sediments in Rauchenwarth (Lower Austria, district of Bruck an der Leitha, "Pfaffenöden", 48°04'05" N, 16°32'28" E). At the time of the study, in late summer, the area was still very rich in flowers. Despite intensive searching, the first author was initially unable to detect the cuckoo wasp *E. purpuratus* on two survey days in August and September 2021. Only in the late afternoon of the second day, a remarkable observation was made, which is described in detail.

A female of *E. purpuratus* sat on a sparsely vegetated spot on the ground (Fig. 3). When the first author approached, it showed no escape reaction. *E. purpuratus* is considered a highly endangered species, and therefore protected in some countries (e.g., SCHMID-EGGER 2010), and generally should not be collected, unless absolutely necessary (e.g., for research, and then in small numbers). However, since a specimen was needed for a barcoding study, the first author decided to collect the cuckoo wasp. The first attempt, using an insect net, failed since the wasp escaped; this was clearly visible. However, to the first author's confusion and surprise, there were three other *E. purpuratus*-females inside the net. This means that there must have been – at least – a total of four cuckoo wasp females within close proximity, which should be considered extraordinary as this is one of the rarest cuckoo wasp species in Europe. The captured specimens were not killed but rather kept inside an empty box.

Such an accumulation of several individuals within only a few square centimetres was reason enough to conduct a more comprehensive search for the species in the area. And indeed: On a sparsely vegetated loess area, in close proximity to the previous collection



Figs 1–2. (1) *Podalonia hirsuta* returns to the place where it deposited the caterpillar and examines it. The process repeated several times. (2) *Podalonia hirsuta* in search of a nesting place.
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Figs 3–5. (3) A female of *Eucharoeus purpuratus*. (4) This female sits on a leaf and observes its host. (5) In the process, it turns depending on the position of its host. The cuckoo wasp remains in this observation position for at least 40 minutes and focuses its gaze on the digger wasp or its prey. © H. Wiesbauer.

spot, a sand wasp of the genus *Podalonia* was discovered. The wasp seemed a little agitated and within a few seconds returned to a specific plant where an owl moth caterpillar (Noctuidae) was located (Fig. 1). The wasp investigated the larval food source and shortly thereafter went off in search for a suitable nest location (Fig. 2). Its search radius covered about one metre. After some brief digging attempts, it aborted the mission and returned to the caterpillar in order to inspect it again. It repeated this process several times.



Fig. 6. The caterpillar is a noctuid, probably *Chloantha hyperici*. © H. Wiesbauer.

Then a truly remarkable observation occurred: An *E. purpuratus* female, possibly the one that evaded the first author during his capture attempt, sat about 40 cm away from the caterpillar on a slightly elevated leaf and observed the sand wasp. It was never completely still, constantly turning, tracking the location of the sand wasp (Figs 4, 5). As if controlled by an invisible magnet, the cuckoo wasp always followed the actions of its host. Apparently in order to gain a better position for its observations, it pivoted up to 120 degrees around its own axis just to return to its original position moments later.

The sand wasp was clearly irritated by these actions and after half an hour, it still had not started building its nest although the afternoon was coming to an end. This situation appeared to have resulted in a stalemate: Whoever would stop paying attention to the caterpillar first, would lose. In an attempt to increase pressure on the sand wasp, the first author decided to release two of the previously captured *Euchroeus* females. Unfortunately, this was not successful as the two cuckoo wasps flew off immediately and never returned. However, the original cuckoo wasp was still in the same spot and observed the happenings – at this point, already for more than half an hour.

As dark clouds started approaching and time had continued to pass, the first author decided to capture the caterpillar along with the sand wasp in order to conduct a proper species identification. The sand wasp turned out to be *Podalonia hirsuta* and its larval prey was a noctuid caterpillar (Fig. 6), most likely *Chloantha hyperici* (DENIS & SCHIFFERMÜLLER, 1775), though unfortunately there are several species with a similar wide whitish lateral stripe (Peter Buchner, pers. comm.). The caterpillar, which had been placed in alcohol, was subsequently brought to Dominique Zimmermann (Natural History Museum Vienna) who investigated the specimen by Micro-CT. The result showed that eggs had not been deposited inside the caterpillar by the cuckoo wasp, as no evidence of egg deposition was found inside the caterpillar. Given the behaviour of the cuckoo wasp, this would have been very unlikely.

Discussion

A syntopic and synchronous behaviour of host and parasite initially does not provide real evidence of a true connection. However, due to the herein described behaviour of the cuckoo wasp, this may well be considered an indirect piece of evidence for this host-brood parasite relationship. The clear interest in *P. hirsuta*'s larval food source by several *E. purpuratus* females shows that this is most likely the cuckoo wasp's host animal. The presented observations are consistent with those reported by MOLITOR (1935).

Two other published notes reported associations between *Podalonia* and *E. purpuratus* or closely related taxa. TSUNEKI (1947) reported a similar case from Inner Mongolia with four females of *Euchroeus* (*purpuratus*) *mongolicus* following a female of *Podalonia caucasica* (MOCSÁRY, 1883) [as "*Ammophila caucasica*"] transporting a caterpillar to her burrow. The four *Euchroeus* were moving "arranging in a line, keeping a subequal interval between them and always redirecting their head toward the *Ammophila* and also toward the breeze, according to the rules of attacking the prey among the carnivorous animals. The *Ammophila* seemed to feel the danger and often stopped her step, dropped her prey on the ground and searched for the enemy. The pursuers are bold enough and when the hunter halted they also halted on the leaves of the grass near by, keeping their row on the lee and looking on the hunter who were running about in excitement."

LINSENMAIER (1968) reported another observation in Canton Wallis, where two *E. purpuratus* females were observed flying together following a prey-carrying *Podalonia* [as "*Ammophila*"].

In Guelmim (Morocco), Thomas J. Wood recently collected several specimens of *E. purpuratus consularis* DU BUYSSON, 1896 flying with *P. hirsuta* (identification by Christian Schmid-Egger).

Although the host-brood parasite relationship between *E. purpuratus* (and related taxa) and *Podalonia* seems to be confirmed, some questions remain unanswered and – given how rare this cuckoo wasp is – may be difficult to answer moving forward:

Does *E. purpuratus* deposit the eggs inside the sand wasp's nest or on the outside?

Is *E. purpuratus* specialized in Central Europe on *P. hirsuta* or does it also target other *Podalonia* species?

Why is *E. purpuratus* so rare given the common occurrence of its host? Does the larval food source of the sand wasp play a role?

How common is a group harassment and what ecological factors trigger it?

Although *E. purpuratus* is one of the rarest cuckoo wasps in Europe (e.g., SCHMID-EGGER 2010), its Austrian population may have slightly increased during the last few years (ZETTEL & SCHODER 2018; unpublished data), possibly due to climate change. Against this background, there is hope that further observations will succeed in answering the questions raised definitively.

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