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Defensive behaviour of a moth (Crambidae: *Eoophyla* sp.) that mimics jumping spiders (Araneae: Salticidae) in tropical India

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Numerous insect species exhibit visual cues resembling the frontal appearance of salticid spiders, often accompanied by movements reminiscent of the aggressive or agonistic displays observed in these arachnids (Hill et al. 2019; Hill 2022). This intriguing observation prompted a comprehensive review of wild populations from 15 lepidopteran genera, revealing a consistent appearance of an archetypal pattern. This pattern suggests potential mimicry, and a deeper understanding of the known biology of each genus holds promise in unraveling the significance of this apparent mimicry (Hill 2022).

Moths displaying this archetypal pattern may exhibit a higher survival rate compared to other moths (Rota & Wagner 2006). Hill's (2022) hypothesis suggests that salticid spiders selectively target individuals with less effective mimicry. The diminished predation success may arise from interrupted or delayed predatory responses or the provocation of divergent reactions to these mimics.

This hypothesis finds support in earlier observations. Rota and Wagner (2006) studied the reaction of neotropical salticids (*Phiale*) to moths (*Brenthia*) that displayed patterns resembling the eyes and crouched legs of salticid spiders. This phenomenon underscores an advanced visual discrimination capability in salticid spiders, enabling them to discern these patterns and associated behaviors. Overall, the interplay between predator and prey, as revealed through mimicry patterns, offers a fascinating avenue for further exploration in the intricate world of arthropod interactions. However observations of related behavior in a natural environment are lacking.

During a field survey on moths conducted at Simbalwara National Park (Figure 1; 30.425626N, 77.483367E), Dhaula Kuan, Himachal Pradesh, we observed the interaction of a salticid-mimicking moth (Crambidae: *Eoophyla* cf. *peribocalis*) with a female *Plexippus paykulli* (Salticidae). The preceding night, (20:00-22:00, 2 July 2022), we deployed light traps to assess moth diversity in the area. The traps attracted hundreds of moths, and by the next morning, 20-30 moths remained on the trap, with some being consumed by house lizards, and others falling prey to spiders, notably the salticid species *P. paykulli*. On 3 July, at 10:00 (AM), we observed this female *P. paykulli* carrying a small, dark-colored moth of comparable size and feeding on it, on a vertical wall. In close proximity, an *Eoophyla* moth rested in its typical position, with hindwings concealed under the forewings and the anterior part of the body raised.

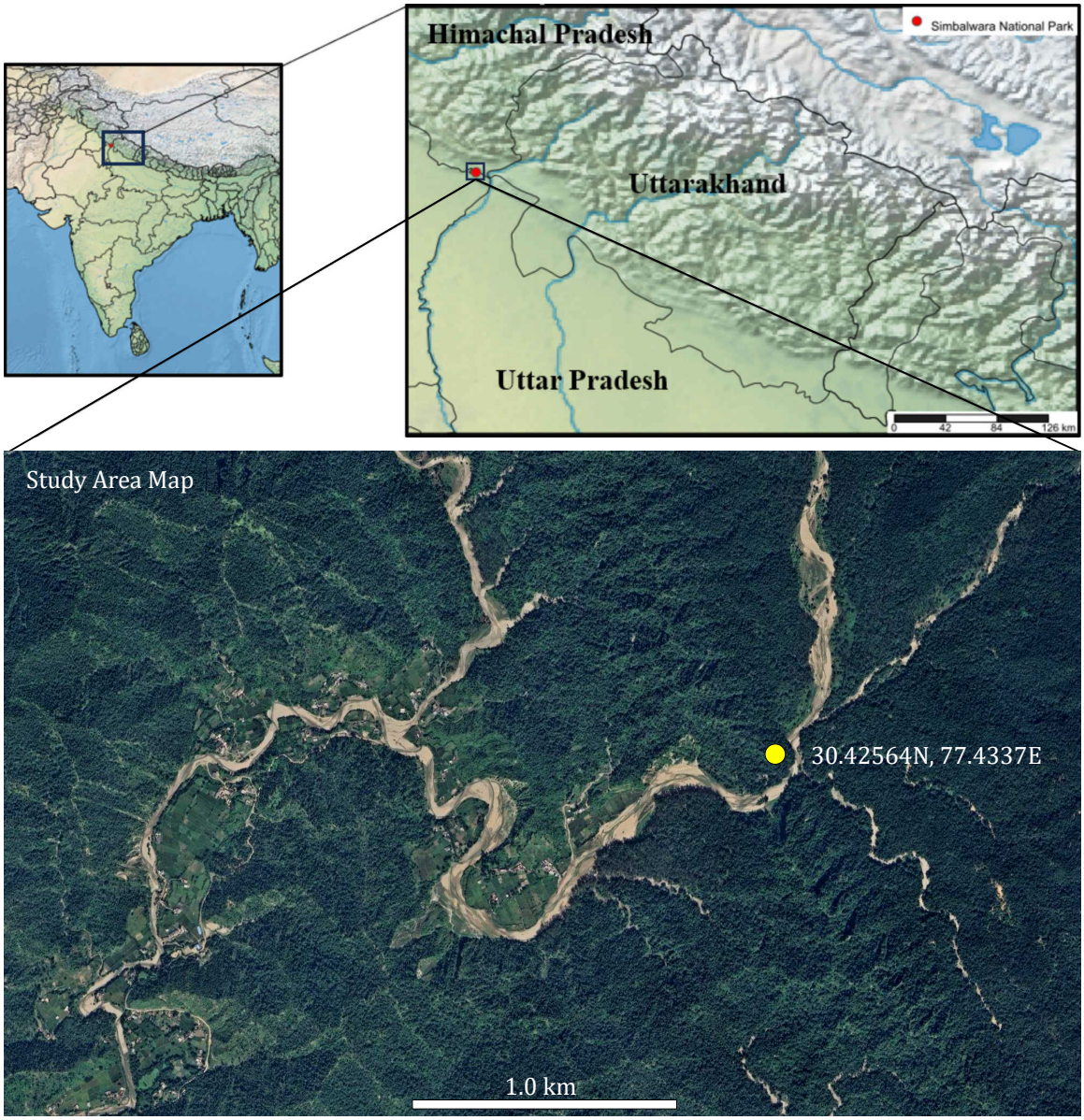

Figure 1. Location of the study site at Simbalwara National Park in Himachal Pradesh. Satellite image produced with QGIS.

Given that *Eoophyla* sp. moths exhibit hindwing patterns mimicking Salticidae (with one mimic pattern on each hind wing), we deliberately sought to observe the behavior of both the moth and its predator. By tapping behind the wall, we directed the salticid toward the moth. The *P. paykulli* female, despite holding prey, apparently did not perceive this disturbance as a threat, but faced the *Eoophyla* moth in front of it. From an initial distance of more than 1 meter, this spider gradually approached the moth. Then this spider dropped its prey while facing the moth. Simultaneously, the moth changed the position of its wings without moving its legs from the surface, exposing the patterns that mimic a salticid on the rear wings. As this *P. paykulli* approached the *Eoophyla*, it refrained from attacking even within striking distance, despite the moth's body size represented potential prey. Opting to maintain a cautious distance, the spider provided the moth with an escape opportunity. Throughout the observed sequence, the moth subtly adjusted its position between resting states, apparently reacting to the Salticidae spider. Both the spider and the moth initially maintained their respective positions at a distance of approximately 6-7 cm., and then the moth flew away. Subsequently we were able to document related behavior with photographs (Figures 2-5).

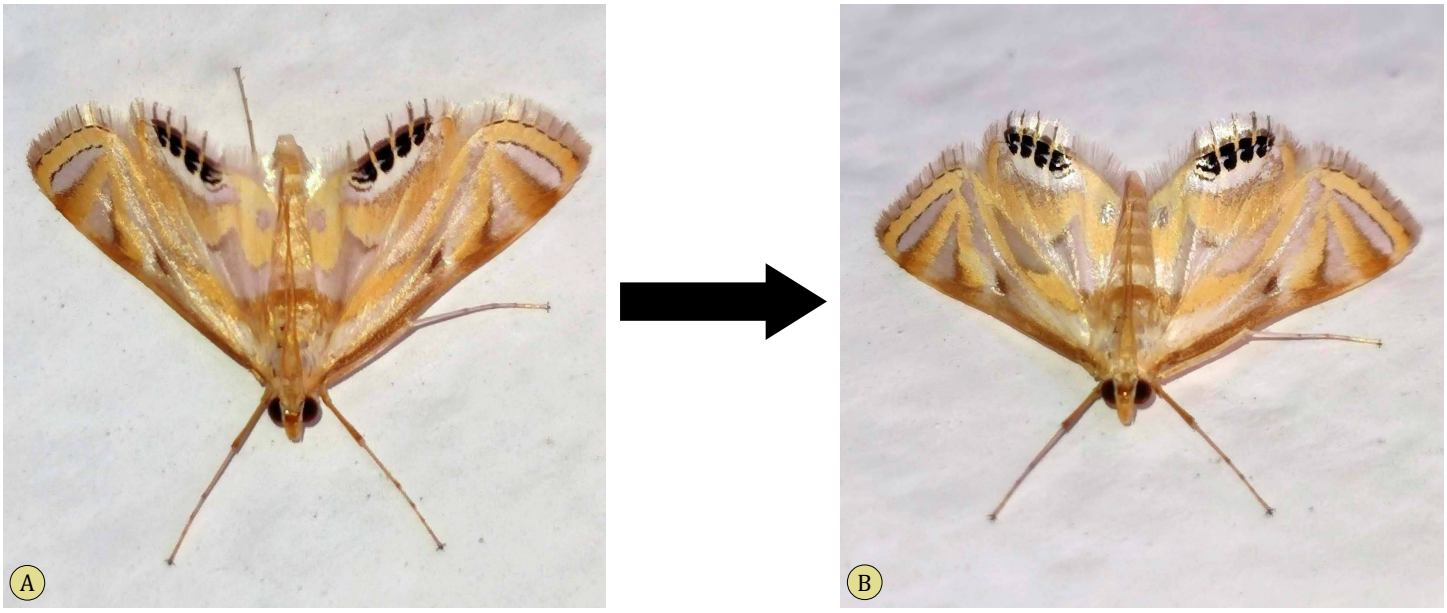

Figure 2. *Eoophyla* before (A) and after (B) raising its hindwings to display the image of a salticid in two directions, on a vertical wall.

Figure 3. A spider' view of a *Eoophyla* with elevated hindwings, from the front (A), and from a more lateral position (B-C). **B-C,** Note that, with more direct illumination (C), reflection in the "eyes" of the salticid image on the hindwing can be seen.

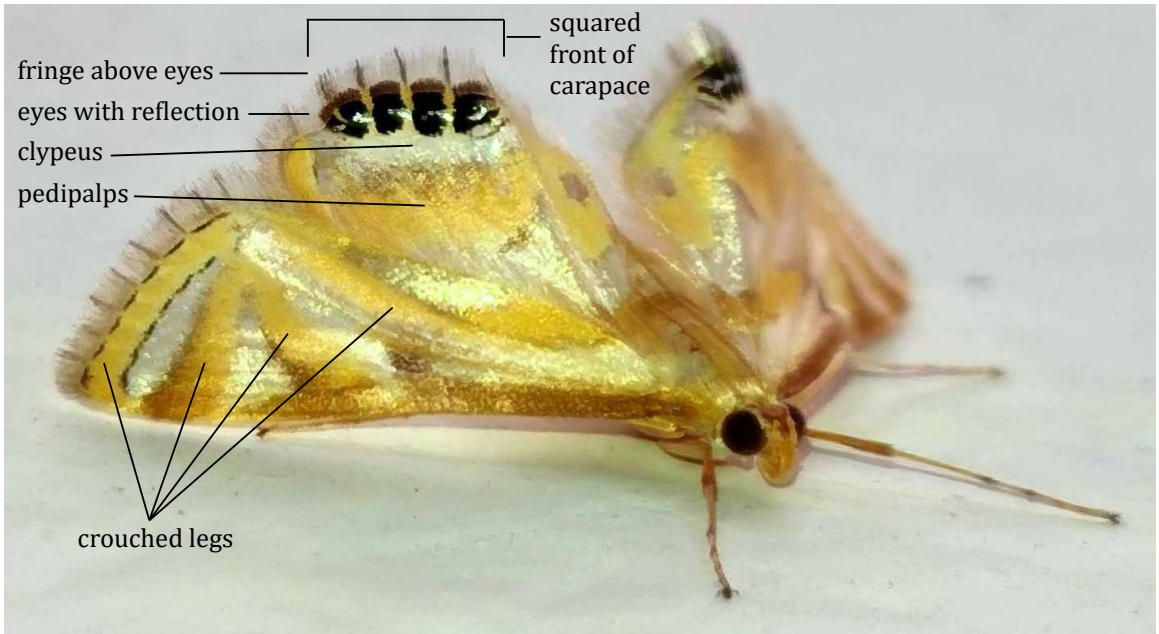

Figure 4. Archetypal features displayed on the raised wings of *Eoophyla* (based on Hill 2022).

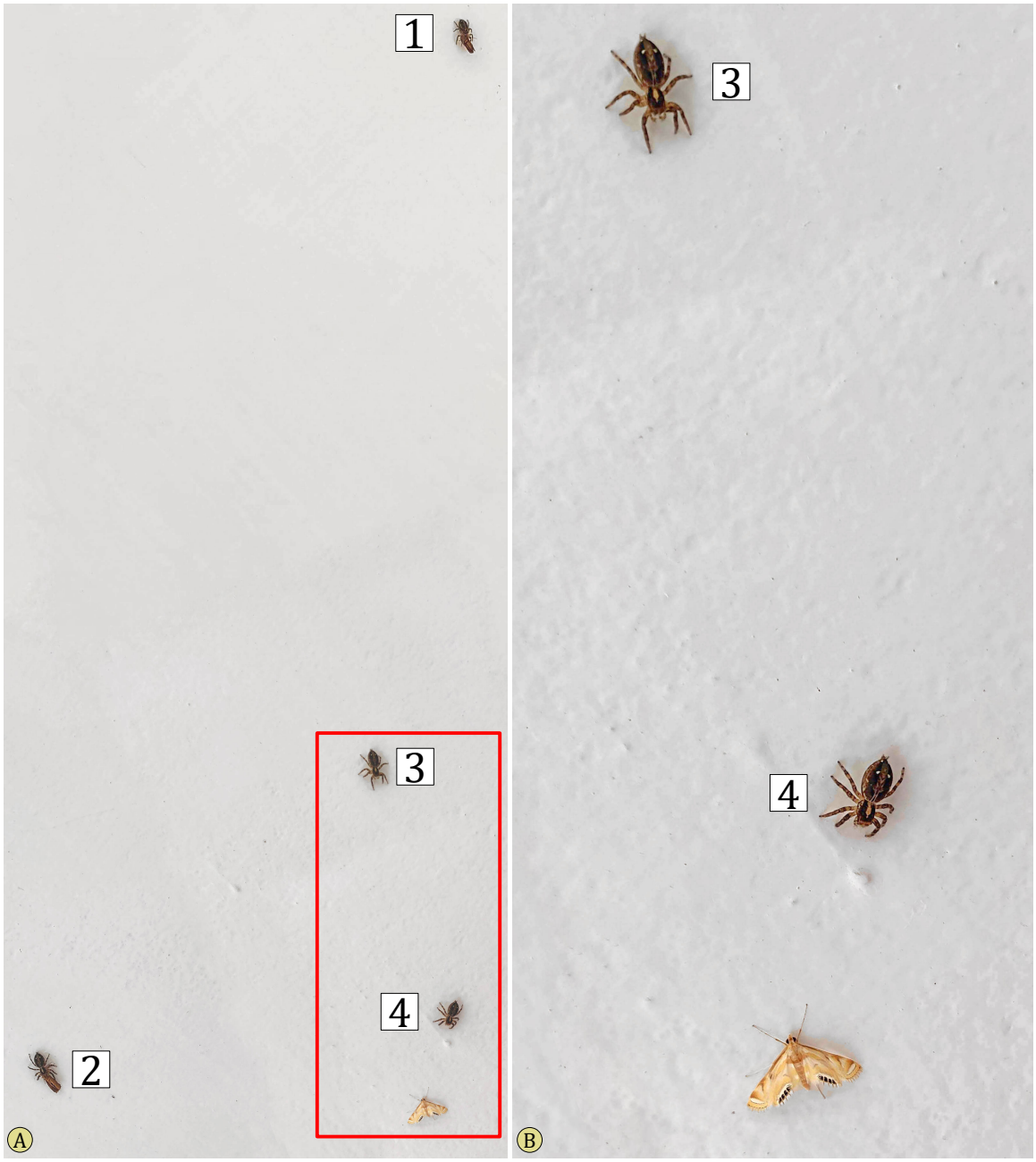

Figure 5. **A,** Composite image showing four successive positions (1-4) occupied by a female *Plexippus paykulli* on a vertical wall, near a stationary *Eoophyla* that was displaying its hindwings. Initially (1-2) this spider fed on a captured moth, but about 2 minutes later (3-4) it approached the Eoophyla from above. **B,** Detail of inset from (a).

While numerous Lepidoptera across diverse clades exhibit a hypothetical salticid archetype, it's crucial to note that the majority of species in these clades do not display this characteristic. In an extensive review by Hill (2022) of thousands of lepidopteran species, he identified a significant yet relatively small number that appear to carry an image resembling a salticid. Key factors associated with this image include diurnal activity, small size corresponding to salticid spiders, and a habit of displaying either the dorsal (usually) or ventral side of the wings at rest. The reason why this image manifests in only some species meeting these criteria, as opposed to most, remains unknown. It can be speculated that in many cases, the presence of salticids influences the selection of detailed scale patterns or wing ornamentation on a smaller scale less relevant to avian predators (Hill 2022).

Salticids are among the few groups known to observe prey or conspecifics at such a detailed level. There are alternative hypotheses beyond the predator distraction concept (where salticids act as the predators) worth considering. One is the notion that the image of a salticid is threatening to more significant predators of Lepidoptera. However, there is currently no evidence supporting this idea, and salticids themselves are vulnerable to birds, lizards, or wasps capable of perceiving these signals. The null hypothesis, suggesting these patterns are merely random, seems improbable given the convergent evolution of this pattern in diverse clades. Another hypothesis, proposing a role in intraspecific communication, falls short in explaining the origin or maintenance of this pattern in widely-distributed lepidopteran populations (Hill 2022).

In conclusion, our study sheds light on the intricate dynamics of predator-prey relationships in the arthropod world, with a particular focus on the mimicry patterns exhibited by the prey of salticid spider. The observed consistent appearance of an archetypal pattern among moths, as highlighted in the field survey at Simbalwara National Park, supports the hypothesis that salticid spiders selectively target individuals with less effective mimicry. This behavior may contribute to the higher survival rates of these moths compared to others. The advanced visual discrimination capability demonstrated by salticid spiders, as noted in earlier studies, further emphasizes the complexity of these interactions. Our findings offer a compelling avenue for future exploration into the evolutionary and ecological significance of mimicry patterns in the intricate world of arthropod interactions.

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