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Spiders Appropriate Empty *Cyana* Moth Cocoons for Nest Armour

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Many spiders, insects and other terrestrial invertebrates re-use organic materials either routinely or opportunistically. The phenomenon can provide illuminating insights into the autecology, community interactions and use of materials by such organisms. Among the Arachnida, one form re-use activities can assume is the secondary colonization or utilization of another arthropod's "nest". This is also found in many Insecta (e.g. Lill & Marquis, 2004). This paper reports a curiously specific variation on this theme in Thailand: the appropriation of abandoned lepidopteran cocoons by spiders. In particular, the re-occupation of the unusually protectively-structured "cage" cocoons made by moth pupae of the lithosiine genus *Cyana* Walker 1854.

Previous accounts include spiders using the retreats of other spiders (e.g. Jackson & Griswold, 1979; Johnson, 1995; Levold & Finch, 2009) and spiders using the abandoned nests of insects (e.g. Haddad & Dippenaar-Schoeman, 2002). Such natural history observations highlight both the ingenuity of the spiders as well as the useful properties of the re-used arthropod-made constructions. The re-occupation of empty *Cyana* "cage" cocoons, described here, merits particular attention because of the cocoon architecture's distinctive defensive properties.

Moths of the genus *Cyana* are found throughout Southeast Asia. They pupate in distinctively defended "cage" cocoons constructed from their larval setae (Holloway, 2001; Monteith, 2008; Leong, 2010). The cage looks like an intricately woven basket of gauze metal wire. To touch, it has the firmness of a fine-meshed flour sieve and provides an effective physical barrier mediating pupal contact with the external environment and defending it from many natural enemies. Within the cage, the pupa is suspended aerially by a silken hammock. Adult moths emerge from their puparia and leave the cocoons by squeezing through the anterior apex of the cage without compromising the shield provided by the woven setae (Monteith, 2008). In the absence of disturbance these vacated cages may persist indefinitely in the environment, offering opportunities for re-occupation and repurposing by other invertebrates.

Observations were made in Chon Buri, Thailand. Surveys for cocoons were carried out in planted copses and secondary forest. At the end of 2013 intensive surveys for moth cocoons on trees and vegetation were made during the end of the phenological window (Nov–Dec) for pupation as part of a study on aspects of the life history of *Cyana* (Hawes, in press). At the beginning of 2014, additional observations of spider-cocoon associations were made when abandoned cocoons were located during other ongoing natural history surveys.

Direct re-use of cages was determined by observations of cages either physically occupied by the spiders themselves and/or by their silk retreats. Spider systematic nomenclature follows the World Spider Catalog (2015). Moths were identified using Cerny & Pinratana (2009). Because the appropriation of cages relies on the absence of the pupated moth and the cages

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of *Cyana* are not obviously interspecifically different (e.g. HOLLOWAY, 2001; LEONG, 2010; MONTEITH, 2008), it was not possible to identify the cages to the species level. However, field-collected pupae from the vicinity that successfully emerged belonged to two species of *Cyana*: *C. bianca* (Walker, 1856) and *C. coccinea* (Moore, 1878).

Two species of spider constructed their own silk retreats in the *Cyana* cages: *Myrmarachne plataleoides* Cambridge 1869 (Salticidae) (Fig.1) and *Cheiracanthium insulanum* Thorell 1878 (Eutichurinae) (Fig. 2). *M. plataleoides* was identified with reference to EDMUNDS & PRÓSZYŃSKI (2003) and *C. insulanum* with reference to DEELEMAN-RHEINHOLD (2001), JÄGER & DANKITTIPAKUL (2010), and CHEN & HUANG (2012).

The phenology of cage re-use roughly corresponds to the first few months after cage construction and the first month after the emergence of imagos. Three cages were physically occupied by two species of spiders and two others had spider silk retreats. Occupants of the latter two cages were provisionally identified as *Cheiracanthium* sp. because their appearance was similar to the retreats of the two *C. insulanum* individuals captured (see below). The retreat of *M. plataleoides* was a thin silk sheet, hung as a low-lying dome attached to a horizontally-inclined vine leaf within the cage. In contrast, *Cheiracanthium* silk retreats were characteristically much thicker and more amorphous in shape.

Although the *Cyana* cocoon cages are not abundant enough in the survey area for appropriation to be a common phenomenon, the protective benefits provided by these shields suggests that where the cocoons are present in numbers, a proportion of them may be expected to be appropriated by spiders. As a strategy it may be classified as opportunistic. However, a closer or more prevalent association might be predicted with more abundant and widely distributed *Cyana* cages. Given the lack of obvious interspecific differences in cage construction among species of *Cyana* moths, the attractiveness of the cages appears to be at the genus level; although with greater *Cyana* abundance or diversity, differences in pupation site might play a greater role in determining which species of spiders re-occupy the cages. With regard to the observations here, because only one of the cages was occupied by *M. plataleoides*, this might be only an adventitious association. However, further cage use by *Cheiracanthium* sp. seems likely. In contrast to *M. plataleoides*, the more substantial retreats of *Cheiracanthium* sp. are probably much less susceptible to weather and the open-air cage environment than the more fragile thin silk-sheets of *M. plataleoides*.

It is interesting to connect these observations of appropriation to elements of the construction 'grammar' of the spiders concerned. Lack of pupal remains – in the absence of some external agency, these empty cases persist with the cages – indicates that some degree of site preparation has occurred in the form of their removal. A non-silk externally derived outer shell is employed by both *M. plataleoides* and *C. insulanum* as an environmental interface in their normal retreats: leaves in the former, woven long grass blades or leaves in the latter. A number of benefits may be incurred from this technique. These instances of re-use may offer clues to the relative significance of such benefits: i.e. given that *Cyana* cages are essentially transparent, it may be that physical defense rather than concealment has greater value for these spiders. Indeed, given that there is no shortage of their usual construction materials of leaves and/or grass blades, appropriation of empty *Cyana* cages is in itself already evidence of a preference, at least among some individuals, for supplementary nest armour over the retreats they would normally construct.

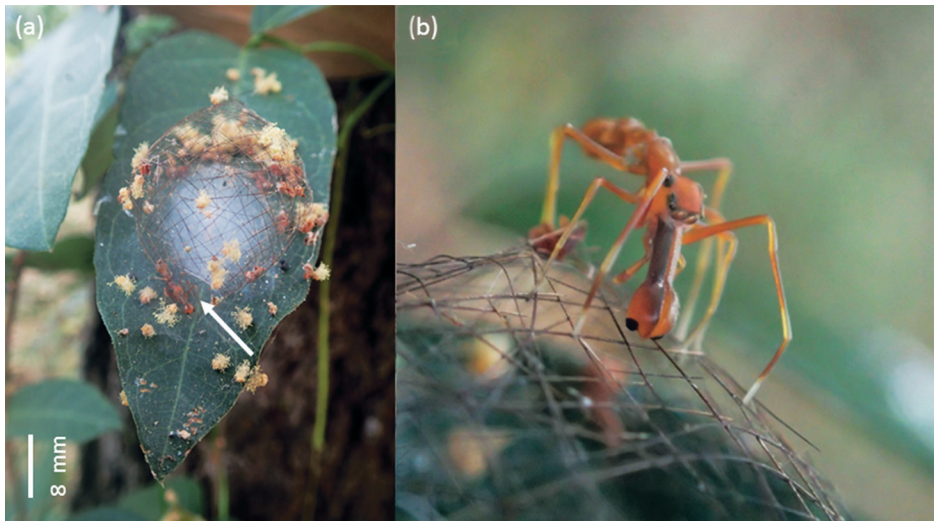

Figure 1. *M. plataleoides* re-using *Cyana* cage (16 December 2013): (a) sheet cocoon on leaf with male patrolling outside, (b) male patrolling roof of cage.

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Figure 2. *Cheiracanthium* silk retreats within *Cyana* cocoon cages found on: (a) 23 December 2013; (b) 14 January 2014; (c) 16 January 2014; and (d) 28 January 2014.