N O T E

Chrysopids (Neuroptera: Chrysopidae) Associated with *Raoiella indica* (Acari: Tenuipalpidae) in Colima, Mexico[1]

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Raoiella indica Hirst (Acari: Tenuipalpidae) is recognized as a major global pest of coconut palm, *Cocos nucifera* L., and also impacts the date palm (*Phoenix dactylifera* L.), other palm species including *Elaeis guineensis* Jacquin (Carrillo et al. 2014, Florida Entomol. 97: 256–261), banana trees (*Musa paradisiaca* L.), heliconia (*Heliconiaceae* spp.), ginger (*Zingiber officinale* Roscoe), and others (Carrillo et al. 2014). The mites damage plants by piercing leaf cells and subsequently sucking on the cellular contents, thus causing tissue chlorosis and eventually necrosis. Large populations on stressed or young plants can even cause plant death (Rodríguez et al. 2007, Rev. Protección Veg. 22: 142–153).

Key Words chrysopids, red mite, predator, *Cocos nucifera*, chlorosis

Control of *R. indica* is largely through the application of chemical insecticide sprays, but given the height of some tree hosts and their presence in areas (e.g., tourist and residential zones) where this type of control raises environmental and public health issues, use of natural enemies is a promising alternative (Carrillo et al. 2014). We, therefore, performed periodic sampling to identify the naturally occurring chrysopids (Neuroptera: Chrysopidae) associated with this pest in Tecomán, Colima, Mexico.

At weekly intervals from 16 February to 21 October 2016, we observed and collected chrysopid larvae on coconut palms infested with *R. indica*. The trees were located on the El Real-Pascuales beachfront of Tecomán, Colima, Mexico (N 18°50′56.50″, W 103°57′15.40″). We used a 10× magnifying glass to observe larvae feeding on *R. indica*. Representative larvae were collected using a fine-hair brush, placed individually in 9-cm petri dishes, and transported to the Centro Nacional de Referencia de Control Biológico (CNRCB) in Tecomán, Colima, Mexico. Once in the laboratory, larvae were placed in 5-cm petri dishes, fed eggs of *Sitotroga cereallela* Olivier (Lepidoptera: Gelechidae), and allowed to develop at 25

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± 2°C until adulthood when they were placed in ethyl acetate and identified according to morphological characteristics.

Sex was identified using taxonomic key of Brooks and Barnard (1990, Bull. Brit. Mus. Nat. Hist. Entomol. 59: 117–286) and male and female genitalia descriptions of Tjeder (1971, Entomol. Scand. 2: 110–188). Species identification was performed using the keys of Tauber et al. (2000, Ann. Entomol. Soc. Am. 93: 1195–1221) for *Ceraeochrysa* and Brooks (1994, Bull. Brit. Mus. Nat. Hist. Entomol. 63: 137–210) for *Chrysoperla*.

We confirmed the identity of *R. indica* by using molecular analysis through the extraction of genomic DNA with the HotSHOT method (Truett et al. 2000, Biotech. 29: 52–54) and sequencing of the *COI* gene fragment. The identified specimens were placed in the Entomophagous Insect Collection (CIE) at CNRCB.

With each weekly sampling, we calculated the relative frequency by using the formula $Fi = (n/N) \times 100$, where Fi is relative frequency; n is the number of samples in which the species appears; and N is the total number of samples collected. We assigned a relative frequency value by using the scale of Masson and Bryssnt (1974, J. Zool. 179: 289–302), with $Fi > 30$ = species occurs very frequently, $Fi > 10 < 30$ = species occurs frequently, and $Fi < 10$ = species occurs infrequently.

Based on morphological characters, we identified *Ceraeochrysa cincta* (Schneider), *Ceraeochrysa claveri* (Navás), *Ceraeochrysa valida* (Banks), *Ceraeochrysa smithi* (Navás), and *Chrysoperla carnea sl*. (Stephens) in these samples. In addition, we obtained and subsequently characterized a *COI* fragment of approximately 650 bp from specimens of *Ch. carnea sl*. because it is currently considered to be a complex including more than 15 cryptic species (Henry et al. 2013, Biol. Rev. 88: 787–808). Phylogenetic reconstruction of the *COI* mitochondrial region by using the neighbor-joining method for that sample showed evolutionary distances equal to those for members of species of the *Ch. carnea* complex from the GenBank database (*Chrysoperla mohave* [Banks], *Chrysoperla johnsoni* [Henry, Wells & Pupedis], *Chrysoperla adamsi* [Henry, Wells & Pupedis], *Chrysoperla downesi* [Smith]), thus supporting the conclusion that the specimen we collected belongs to the *Ch. carnea sensu lato* complex as per Henry et al. (2013). Canard and Thierry (2007, Ann. Museo Civico Stario Nat. Ferrara 8[2005]: 173–179) previously noted that the specific name *Ch. carnea* caused confusion and that species separation may be through analysis of mating calls of live insects of both sexes.

With the exception of *Ch. carnea sl*, the four species of *Ceraeochrysa* showed remnants of red mites on their dorsal surfaces. This is a behavior that enables the insect to transport residues from its prey and other organic materials to provide protection against its natural enemies (Adams 1982, Neur. Int. 2: 69–75).

A total of 713 chrysopid specimens were identified. *Ceraeochrysa cincta* and *C. claveri* were present during all 9 mo of the sampling. *Ceraeochrysa cincta* was collected most frequently (586 individuals), whereas 116 specimens of *C. claveri* were collected. Both species exhibited a high relative frequency value (Fi) (Table 1). These factors likely indicate adaptation of *C. cincta* to the coastal zone conditions in the state of Colima. To the contrary, only seven specimens of *C. valida* (Banks), three specimens of *C. smithi* (Náva), and one of *Ch. carnea sl*. were collected.

Table 1. Relative frequency of different species of chrysopids associated with *R. indica* in coconut palms of the El Real-Pascuales beach front in Tecomán, Colima, Mexico, from February to October 2016.

Species	Relative frequency (%)	Classification
C. cincta	100.00	Very frequent
C. claveri	38.50	Very frequent
C. valida	19.00	Frequent
C. smithi	12.90	Infrequent
Ch. carnea sl	3.22	Infrequent

Ceraeochrysa larvae feed on different agricultural pests, including mites (Tauber et al. 2000). In Mexico, species of this family have been observed preying on mites in fruit trees such as citrus, *Citrus* spp., and guava, *Psidium guajava* L., in the states of Colima, Michoacán, Nuevo León, and Tamaulipas (Tauber and de León 2001, Ann. Entomol. Soc. Am. 94: 197–209), in addition to coconut palm.

We found citations of only *C. claveri*, *Chrysopodes collaris* (Scheider), and *Chrysopa cubana* (Hagen) as preying on *R. indica* (González et al. 2013, Rev. Protección Veg. 28: 215–218; Carrillo et al. 2014). Thus, our study is the first report of natural predation of *C. cincta*, *C. valida*, *C. smithi,* and *Ch. carnea sl*. on *R. indica*. These chrysopid species, especially *C. cincta* and *C. claveri* that are the most abundant, might be considered for biological control agents of *R. indica*.