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Notes and Comments

Behavioral observations of larvae and adults of *Dinurothrips hookeri* Hood, 1913 (Thysanoptera: Thripidae: Panchaetothripinae)

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Dinurothrips hookeri Hood, 1913 is one of the two species described in the Neotropical genus *Dinurothrips* Hood, 1913. Unlike its congener *D. vezenyii* Bagnall, 1919, known only from southern Brazil, Argentina and Florida (USA) on grasses, *D. hookeri* is more widely recorded in several countries of the Americas (Mound and Marullo, 1996; Hoddle et al., 2012; Lima et al., 2020). *Dinurothrips hookeri* is associated to a wide range of plants, including horticultural and ornamental crops (*Aster, Gerbera* and *Zinnia*) (Wilson, 1975), but damages have been recorded only to banana (*Musa* sp.), mint (*Mentha* sp.), tomato (*Solanum lycopersicum* L.) and sweet potatoes (*Ipomoea batatas* L. (Lam.)) (Callan, 1951; Hoddle et al., 2012; Lima et al., 2016).

Although widespread and polyphagous, few information on behavior of *D. hookeri* is available. Callan (1951) is the only paper dealing with the biology of the species, in which the author reported data on host plants and life cycle duration. The objective here is therefore to provide additional behavioral observations of *D. hookeri* larvae and adults and compare it with other related species.

We observed, under stereomicroscope, populations of *D. hookeri* on *Impatiens balsamina* L. in Piracicaba, state of São Paulo (22°42'45"S 47°37'38"W) in 1997 (April and May) and 2013 (May) and Teresina, state of Piauí (5°2'18"S 42°47'56"W) in 2014 (March to May). The identification was performed after mounting five to ten specimens (including adults and larvae) from each sample on permanent microscope slides following the technique described in Mound and Marullo (1996). Voucher specimens are deposited in Escola Superior de Agricultura "Luiz de Queiroz", Universidade de São Paulo, Piracicaba, Brazil and in Coleção de História Natural da Universidade Federal do Piauí, Floriano, Brazil. Pictures of mounted specimens were taken from Piauí samples with a Zeiss AxioCam ERC 5s attached to a Zeiss Axio Lab A1 phase constrast microscope. Pictures of alive individuals were taken from São Paulo samples under a Zeiss Stemi SV 11 stereomicroscope. Although collected and observed in different dates and sites, no observable distinctions regarding behavior and morphology were noted among the populations.

Adults (Figures 1 and 2) are slow and easy to manipulate. However, in doing so, they eliminate fecal material (droplets) and curve the abdomen. Larval pigment is cleared for microscope mounting (Figure 3), but living individuals are light yellow anteriorly and red on the abdomen, which becomes darker sometime after the molt (Figures 4 and 5). As mentioned by Callan (1951), they constantly carry the fecal droplets on the top of the abdomen and concentrate on the underside of the leaves, along or near the ribs. The droplets are initially clear, then golden yellow and finally black (Figure 4). The drops are hold by means of relatively long anal setae (Figure 3), and fall presumably when the volume is too high to be maintained. Feeding of larvae and adults occurs mainly along or near the central rib, leading to the emergence of silvery, coalescing areas. Information on prepupae and pupae is available in Callan (1951).

Droplet carrying is widespread among larvae of Panchaetothripinae. The authors have observed this in larvae of at least seven species in the subfamily (*Caliothrips phaseoli* (Hood, 1912), *Heliothrips haemorrhoidalis* (Bouché, 1833), *Heliothrips longisensibilis* Xie et al., 2019, *Helionothrips errans* (Williams, 1916), *Hercinothrips femoralis* (Reuter, 1891), *Retithrips syriacus* (Mayet, 1890) and *Selenothrips rubrocinctus* (Giard, 1901)). A possibility to explain this behavior is that these larvae are more vulnerable to predators, as live on leaf surfaces and are usually exposed. Adults, that are more agile and have the option of flying away, might escape more easily and rarely produce such elements. *Dinurothrips hookeri* adults, however, are also slow and equally produce fecal droplets when disturbed. In addition, the droplets would only be beneficial for Thripidae species exclusively on exposed surfaces, as the drop would get in the way for species in small spaces, such as in flowers.

Apart from Panchaetothripinae, the authors have observed similar droplets being produced by larvae of *Neohydatothrips fimbriatus* (Hood, 1954) (Thripidae: Sericothripinae), also living on leaves (yet unidentified plant), in Cuiabá, state of Mato Grosso. In addition, species of Thripinae such as *Frankliniella occidentalis* (Pergande, 1895) and *Thrips parvispinus* (Karny, 1922) (Thripidae: Thripinae) are reported with similar behavior (Maharijaya et al., 2011) on leaves of pepper. In the remaining Thripidae subfamily, Dendrothripinae, this behavior has neither been recorded

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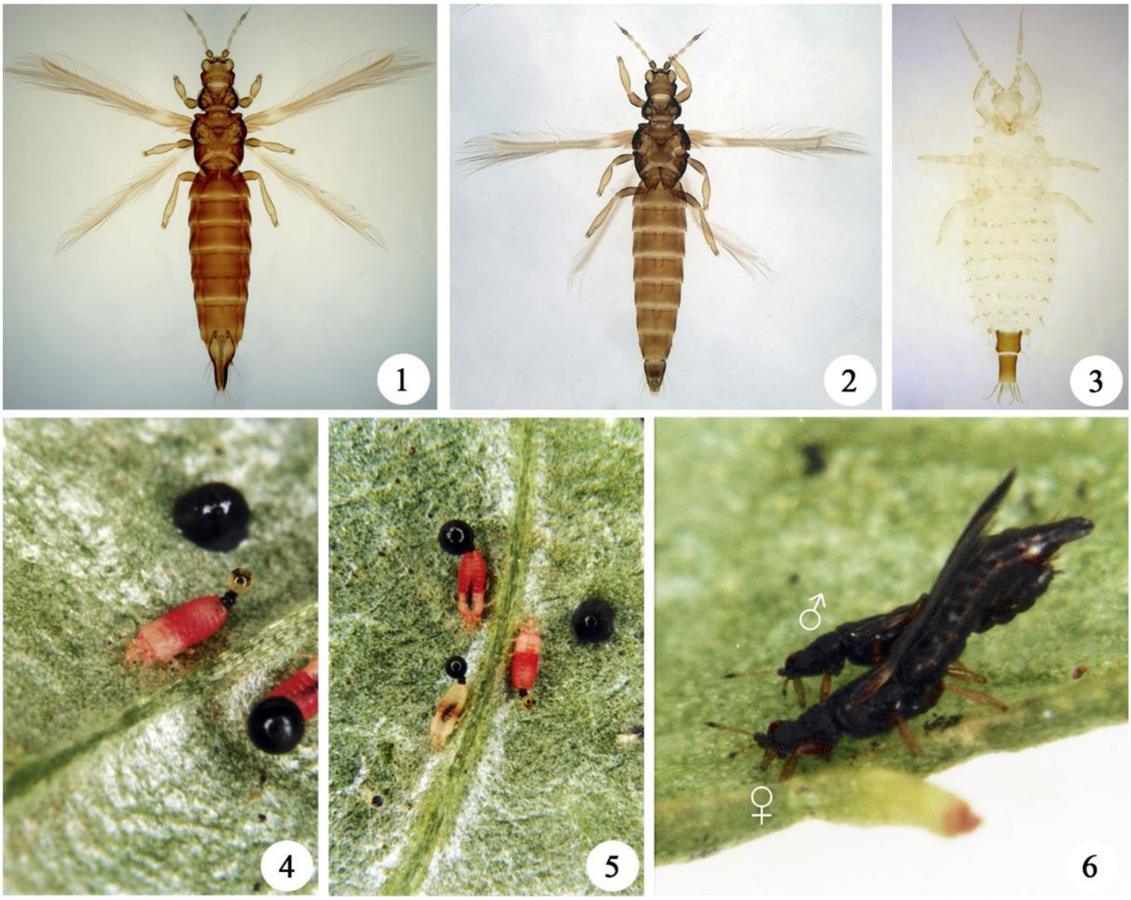
nor observed by the authors. Larvae of Dendrothripinae are sensibly smaller than most species of other Thripidae families and usually jump high, thus a possibility is that it is the small size and behavior that help them hiding from possible threats. Species of Tubulifera, such as *Bagnalliella yuccae* (Hinds, 1902), *Callococcithrips fuscipennis* (Moulton, 1968), *Gynaikothrips ficorum* (Marchal, 1908) and *Suocerathrips linguis* Mound and Marullo, 1994 are reported to produce similar droplets when disturbed (Howard et al., 1983; Howard et al., 1987; Tschuch et al., 2005, 2008).

Knowing the chemical compounds of the fecal droplets helps understanding how it aids larvae to defend themselves. In *B. yuccae*, y-decalactone is the main allomonium, while pentadecane and hexadecyl acetate are the main components of droplets produced by *G. ficorum* and eicosadienyl acetate in *S. linguis* (Howard et al., 1983; Howard et al., 1987; Tschuch et al., 2005). In Thripidae, dodecyl and decyl acetate were identified in fecal droplets of *F. occidentalis* larvae (Teerling et al., 1993). All of these components are reported as insect repellent.

Courtship and copulation in *D. hookeri* follow a sequence of steps: (1) initial contact between both sexes through antennation; (2) male rides a female, on the upper or lower face of the leaf; (3) with the fore legs, males hold the pronotum of the female and with the median and hind legs, it holds the abdomen and wings; (4) male bend the back of the abdomen and insert aedeagus into the female genitalia; (5) male releases the female pronotum, staying dorsolaterally to the female in a "V" shape position (Figure 6); (6) male moves away laterally pulling the female abdomen until they separate. During courtship, other males may approach. When this happens, the male involved in the courtship curves the abdomen up and shakes it, chasing away others, which may also repeat the same behavior. This behavior was not known for the species, as the populations studied by Callan (1951) included females only, which reproduced by parthenogenesis. Similar copulation has been reported in other thrips species, such as *Aeolothrips fasciatus* (Linnaeus, 1758), *Echinothrips americanus* Morgan, 1913, *F. occidentalis*, *F. schultzei* (Trybom, 1910) and *Scirtothrips aurantii* Faure, 1929 (Stannard, 1968; Terry, 1997; Milne et al., 2007; Rafter and Walter, 2013; Krueger et al., 2017).

Oviposition occurs on the upperside of the leaf, petiole or stem. Females raise the posterior and medial thirds of the abdomen from the substrate while head, thorax and anterior third of the abdomen are in contact with the host, much like a "bow" position. The wings are tilted towards the surface. The female, then, inserts the ovipositor on the leaf tissue to lay the eggs.

Among common flower Thripinae, aggregation is presumed to work primarily to mate, with minimal



Figures 1-6. *Dinurothrips hookeri*. Female (1); male (2); second instar larva (3); second instar larvae with droplets (4-5); adults in copulation (6).

feeding or oviposition (Terry, 1997). In leaf-feeding Panchaetothripinae, on the other hand, the habitat is used for egg laying, feeding and mating, and aggregations with immatures and adults of both sexes are common, as it was observed with *D. hookeri*. Females were more abundant than males, probably as result of thelytokous parthenogenesis. Other thripids such as *Anaphothrips obscurus* (Muller, 1776), *Hercinothrips femoralis* and *Thrips tabaci* Lindeman, 1889 exhibit this reproductive method, although *T. tabaci* Lindemann, 1889, as well as *T. nigropilosus* Uzel, 1895, also reproduces via arrhenotoky (Stannard, 1968; Varga, 2008; Li et al., 2014; Gill et al., 2015). However, larvae were more numerous than adults, that may disperse to other feeding or mating sites. Males of *D. hookeri* have remarkable U-shaped pore plates on sternites III-VII (Figure 2), which might be involved with pheromone releasing, as in other several unrelated groups of thrips (Mound, 2009). How it specifically works is yet unknown.

Information presented here are basic and were obtained by direct observation. More accurate details on specific parameters can be accessed if long-term studies are performed. *Dinurothrips hookeri* individuals exhibit rather slow movements and are easily manipulated. In addition, rearing technique for the species is available (Callan, 1947). Thus, it can be used as an alternative model to explore more behavioral information among Panchaetothripinae.

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