



Capture suggests the successful introduction of *Sirex* parasitoid in Brazil

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Abstract - Other organisms may be employed in the control of woodwasp besides the nematode *Deladenus siricidicola*. This is the case of the parasitoid *Megarhyssa nortoni*. Its introduction in Brazil occurred with a limited number of specimens and, so far, it has not been possible to assert its establishment. After 20 years from the introduction we have received reports that *M. nortoni* adults were captured in Santa Catarina. We identified in the samples several adults of the parasitoid which suggests their establishment in Brazilian territory.

Captura sugere sucesso na introdução de um parasitóide de *Sirex* no Brasil

Resumo - Além do nematóide *Deladenus siricidicola*, outros organismos podem ser usados no controle da vespa-da-madeira, como o parasitóide *Megarhyssa nortoni*. Sua liberação no Brasil ocorreu com um número limitado de exemplares. Até o momento não havia evidências para assegurar seu estabelecimento. Depois de 20 anos da introdução recebemos relatos de que adultos de *M. nortoni* foram capturados em Santa Catarina. Nós identificamos vários adultos do parasitóide nas amostras deste material, o que sugere seu estabelecimento em território brasileiro.

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The wood wasp *Sirex noctilio* Fabricius 1793 (Hymenoptera, Siricidae) was introduced in many countries where it is considered a pest of several species within the genus *Pinus* (Iede & Zanetti, 2007). Since pine plantations in Brazil occupy 1.6 million ha (Indústria Brasileira de Árvores, 2017) the wood wasp damage has become part of the forestry sector's concerns. The impact of this insect damage in pine plantations in Brazil reached 60% (Iede & Zanetti, 2007) and losses of 6.5 million dollars per year (Oliveira et al., 2013). A more recent evaluation estimated that the pest is affecting some 1M ha, causing US\$ 9 million per year of economic losses (Embrapa, 1989; Iede et al., 2015). In a country

where 1.1% of gross domestic product (GDP) comes from the forestry sector, this amount of impact is very significant (Indústria Brasileira de Árvores, 2017).

Strategies aiming *Sirex* control recommend a combination of silvicultural and biological control measures (Haugen et al., 1990; Iede et al., 1998). Silvicultural treatments can preserve the health and vigor of pines preventing attacks. Management actions as timing selective thinning and restricting pruning and thinning-to-waste outside the wasp flight season can greatly reduce the attack risk (Carnegie et al., 2005).

As an initiative to protect the *Pinus* production chain, the National Program for wood wasp Control (Programa

Nacional de Controle à Vespa da Madeira - PNCVM) was funded by Funcema (Fundo Nacional de Controle de Pragas Florestais). The program made possible to adapt and develop measures of prevention, monitoring, and control of the pest within the principles of the integrated pest management (IPM). The measures were based on the Australian biological control management system using *Deladenus siricidicola* (Bedding, 1968) (Nematoda, Neothylenchidae) which sterilizes female wood wasps, reaching levels of parasitism close to 100% (Iede et al., 1998). The Australian program has been a model for *Sirex* management in the pine-growing regions of the southern hemisphere since the 1960s (Williams & Hajek, 2017). The adoption of these measures adapted to the Brazilian scenario allowed the maintenance of the pest population at controlled levels minimizing economic losses (Penteadó et al., 2012).

Nonetheless, we also used in Brazil other organisms aiming to ensure a wider set of systemic tools. Potential natural biological control such as the parasitoids *Ibalia leucospoides* Hochenwarth, 1785, *Rhyssa persuasoria* (Linnaeus, 1758) and *Megarhyssa nortoni* (Cresson, 1864) (Hymenoptera, Ichneumonidae, Rhyssinae) were already known (Taylor, 1976; Penteadó et al., 2012, 2016). Among the three parasitoids, *M. nortoni* was the most effective in the wood wasp population control when in association with *R. persuasoria* in Tasmania, Australia, with a significant reduction of the pest (Madden, 1988). The larval parasitoid *M. nortoni* is an ectoparasitoid and attacks wood wasp larvae during its later stages of development (Taylor, 1976). The females perforate the wood with their ovipositor until they find a larva of *Sirex*, which receives a sting and is paralyzed. An egg is placed on the host larva and it can hatch in two days, with the larva beginning its feeding on the body of the host. The larval period usually lasts three to five weeks (Hocking, 1968). Most of the individuals of each generation (about 80%) enter diapause in the larval stage, when fully fed, thus presenting a cycle lasting two years. Those who do not enter diapause immediately pupate, with a cycle lasting three to four months (Taylor, 1976). The pupae are located close to the shell and the adults chew the wood to emerge, opening a hole through which they leave (Nuttall, 1980).

The introduction of *M. nortoni* in Brazil occurred as a result of cooperation between the United States Department of Agriculture (USDA), the International Bureau of Biological Control (CABI-Bioscience) and the

University of Tasmania promoted by Empresa Brasileira de Pesquisa Agropecuária (Embrapa) (Penteadó et al., 2015). The release occurred in two phases (Penteadó et al., 2012, 2015), with a limited number of specimens released due to difficulties with the adaptation of the rearing process. The first phase covered seven releases in the state of Santa Catarina between 1997 and 1999. In 2003 a new strain was introduced and released in a municipality in the state of Paraná. In addition to the problems with the rearing process (and the small number of specimens released), the trees of one area were felled the following year after the release (Penteadó et al., 2015). Field assessments were carried out in October 2015 in pine plantations in Santa Catarina State, but there was no concrete evidence to ensure that *M. nortoni* introductions had been sufficient for the establishment success. These occurrences affected our expectation of success in the introduction of the parasitoid.

It was included in the procedures of the wood wasp control program a request for reports of the occasional captures of *M. nortoni* by the companies that maintain areas of pine plantations with wood wasp control practices. Due to these reports, in the last two years, Embrapa received accounts that *M. nortoni*'s adults were being captured in the municipality of São José do Cerrito, in Santa Catarina State.

The companies have as a recommendation the record of parasitoid catches that emerge from control logs. Therefore, the captured specimens are normally released just after its record. Upon knowing of alleged *M. nortoni* occurrence we requested the collection of some vouchers directly preserved in ethanol 70 °GL. These samples were received identified with the collection date, geographic position, and collector. All samples were examined directly in ethanol under a stereomicroscope (80x zoom). Some of the samples were dry mounted with an entomological pin to be deposited as collection vouchers. Photographic images were taken directly with a reflex digital camera Canon EOS 1100D. We captured 15 pictures representing different levels of the focus of the mounted insect. Images were electronically aligned (under the option "align and balance") and stacked (under the option "weighted average") in Combine ZP (Hadley, 2010). Color levels were adjusted with the GNU Image Manipulation Program (GIMP... 2019). Dry mounted identified samples were deposited in the Entomological Collection Padre Jesus Santiago Moure, Department of Zoology, Federal University of Paraná

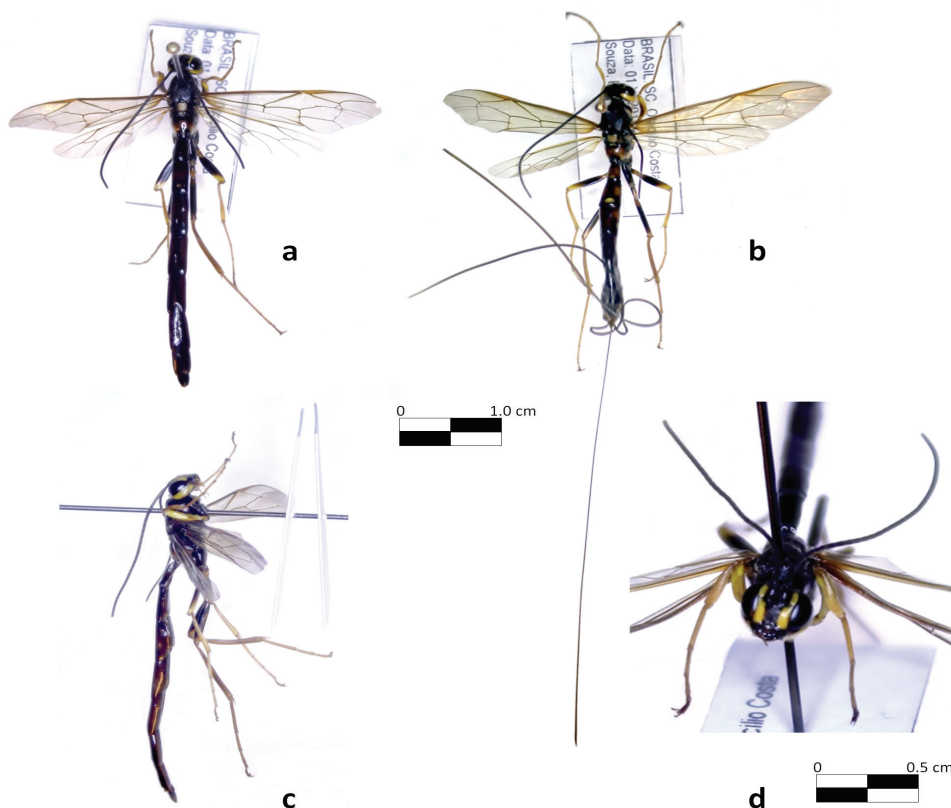
(DZUP, Curitiba, Parana State, Brazil). Vouchers were also kept in the reference entomological collection of Embrapa Florestas (Colombo, Parana State, Brazil). Some comparative keys to hymenopteran parasitoids associated with *Sirex* were used as Schiff et al. (2006), Standley et al. (2012), Pook et al. (2016) to confirm identification. It should be mentioned that after the capture of these specimens the companies returned to release to the environment any live adults of *M. nortoni* captured from the control logs.

More than a hundred specimens were received all positively identified as *M. nortoni* originated from the municipality of São José do Cerrito (27°39'45" S, 50°34'48" W). Males and females were represented in sampled material (Figure 1). These catches coincide

with the known adult emergence period and with the period when the wood wasp is at a more advanced stage of larval development (approximately from November to February).

This find is the first support to the hypothesis that populations of *M. nortoni* are indeed established in Brazilian territory. It is possible to infer that there is support capacity for the parasitoid maintenance in Brazil. Based on these finds we expect that mass production can be retaken as a promising aid tool in wood wasp control in addition to the standard use of the nematode in the PNCVM. This inclusion aims at the refinement of the processes of laboratory rearing and reintroduction in the *S. noctilio* occurrence areas in order to achieve even more effective control of the damages caused by the wood wasp.

Figure 1. *Megarhyssa nortoni* male and female specimens captured in Santa Catarina State, Brazil. Male, dorsal view (a); Female, dorsal view (b); Male, right lateral view (c) and Male, head frontal view (d).



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